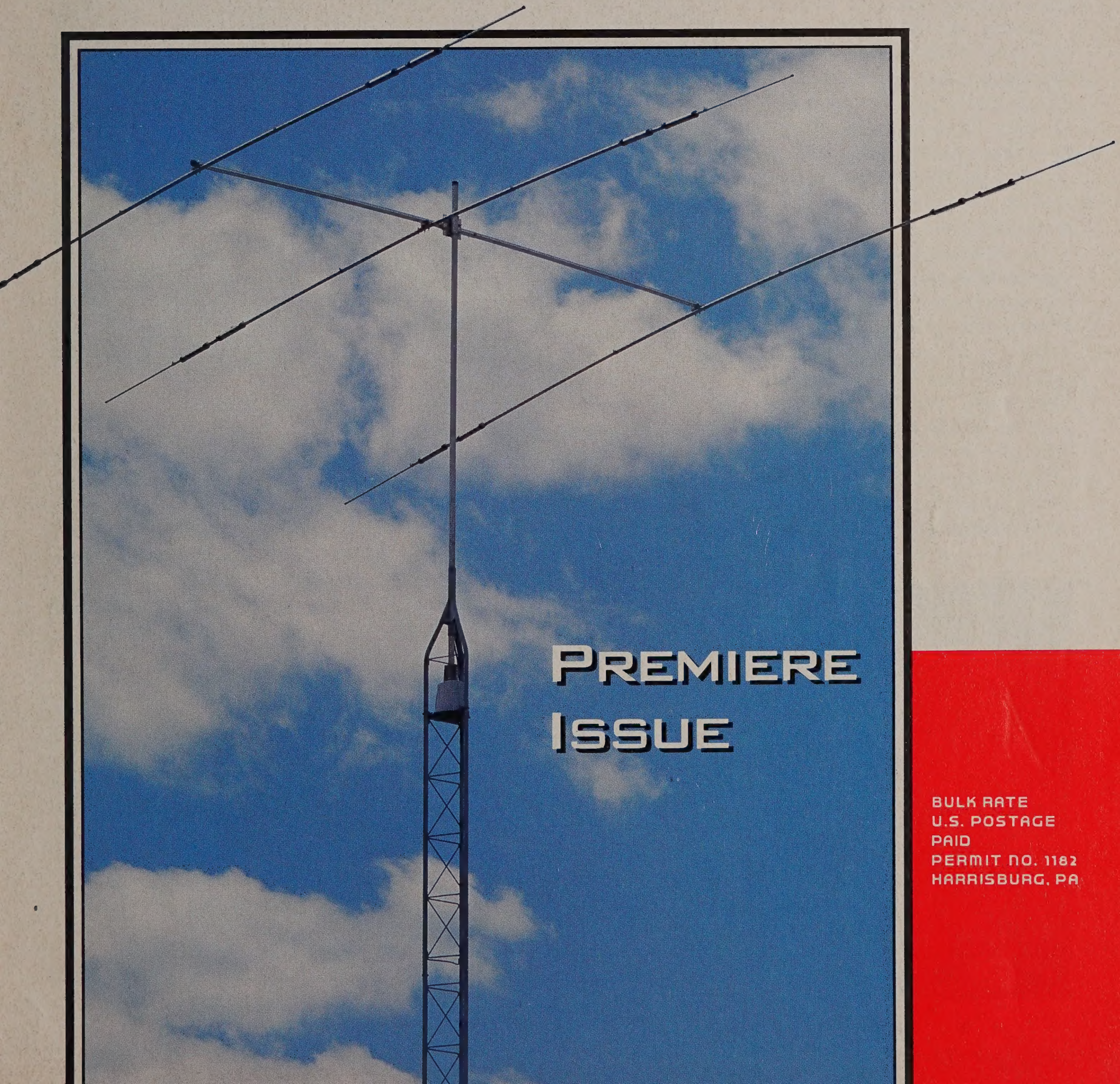
JULY/AUGUST 1990

THE AMATEUR ELECTRONIC COMMUNICATIONS MAGAZINE

BEAM



PREMIERE ISSUE

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EDITOR'S NOTES

Now! A Free Magazine for Hams

Welcome to the premiere issue of BEAM, a new concept in amateur radio magazines -- a "freebie!"

Initially, BEAM will be mailed out every other month (in July, September, November, January, March and May), but ultimately we plan for it to be a monthly magazine, totally supported by advertising, with more pages, more articles, and more product information for you.

To continue receiving BEAM, merely fill out one of the qualifying forms in the centerspread, fold it twice and tape it, put a 25-cent stamp on it, and drop it in the nearest mailbox. (You see, like the "free lunch," your "free subscription" to BEAM really costs you a little time and some postage.)

If you share your BEAM with a friend, have him or her return the other qualifying form. Or, if you've received two copies of this issue due to an overlap in our mailing lists, please accept our apologies -- and pass one on to a friend! If you have ham friends in other countries, tell them they, too, can get it by paying a subscription fee.

We hope you enjoy this newest of ham magazines and will want to continue receiving it -- and writing for it -- or advertising in it. We welcome articles on the fun of ham radio -- equipment building, DX, ragchewing, computerized hamming, antennas and propagation, VHF operations, technical notes, stories about the good old days, and back-to-basic tutorials for beginning hams. You'll earn fame and happiness when you see your byline in BEAM.

Write or phone us with your ideas, comments, opinions, etc., at BEAM, P.O. Box 650, Boalsburg, PA 16827, (814) 466-6559.

About the Editors

Managing editor (and inveterate ragchewer) "Josie" Chesworth, K3SJS since 1962, graduated in advertising from Penn State and spent 14 years with the Penn State Alumni Association. She has edited four magazines and published more than 200 feature articles.

Technical editor Tom Chesworth, W3IA, is an amateur extra class who was first licensed in 1958 and enjoys contesting on CW. Holder of three Penn State degrees, Tom is a registered professional engineer and electronics consultant. He and Josie also publish the bimonthly *Electromagnetic News Report (ENR).*

QBE?

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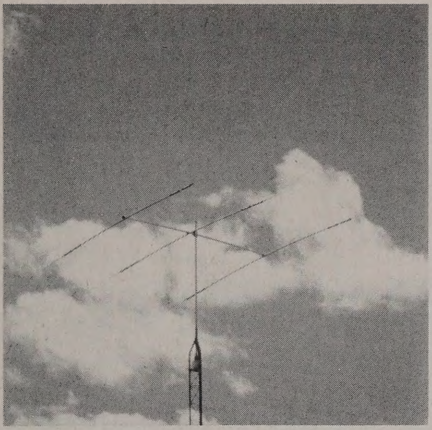

COVER: The antenna on the cover of this premiere issue of *BEAM* is Cushcraft's A3S World Ranger tribander for 20, 15 and 10 meters. (Photo courtesy of Cushcraft Corp.)

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DXpedition to Tangier Island

by Al Brogdon, K3KMO

After being closed down during World War II, amateur radio again came to life in the fall of 1945. American troops still on active duty all over the world were licensed by the FCC for their foreign operation.

These world-wide U.S. call signs were formed by using the letter K, followed by a second letter that was usually the initial of the location, a number that corresponded to the nearest U.S. call area, and individual station suffixes. For example, Americans in Tangier, Morocco, were licensed as KT1 stations.

Most of those foreign K call signs have either changed or been dropped entirely. But, with the advent of all the new prefixes for US stations, some of those old prefixes have shown up again.

W3X0 at the 6 meter SSB position. Bill, who writes the column "The World Above 50 MHz" in *QST*, was rewarded for his considerable effort in putting KT4A on 6 meters with almost bone-dry band conditions -- but that's the challenge of VHF! (Notice the essential can of "Tangier Perfume.")

Fast Forward to 1987

Tangier Island, Virginia is a small island (3 1/2 miles long by 1 1/2 miles wide) in the middle of the Chesapeake Bay. Although first sighted by Capt. John Smith in 1608, it was not settled until the 1680's, when a fishing family named Crockett came from Cornwall, England.

During the War of 1812, the British occupied the island and built a fort, which is now underwater and slightly offshore, as the level of the water has risen over the years. Tangier Island was the staging area for the troops that attacked Ft. McHenry in Baltimore and resulted in the writing of *The Star-Spangled Banner*.

Nowadays most of the 800 people on the island work at either crabbing or soft-shell crab farming, with a small tourism industry.

MADRAS

The Maryland Apple Dumpling Radio Society was formed one night over apple dumplings at a Bob's Big Boy restaurant in the Maryland suburbs of Washington, D.C. In its early months, the club was floundering about, trying to find its direction. I invited them to join me on a local DXpedition to Tangier Island. They said sure, they didn't have anything better to do.

KT4A

Jim Durkin, KT4A, lives in the Virginia suburbs of Washington. Although none of us knew Jim, I called him one afternoon, introduced myself, and asked if we could use his call sign for a radioactive trip to Tangier Island for a few days. Jim, a psychiatrist, said we could use the call sign. He also offered us group rates when we got back from our trip. Jim said he wouldn't be able to join us, but would make a schedule to work us.

Publicity and Promotion

The publicity was thorough. We started by sending press releases to U.S. ham magazines. It was carried by *CQ*, *QST*, *World Radio*, *DX Report*, and *Auto-Call* (the Washington-area ham publication). We called Westlink, and they carried an item on the KT4A DXpedition the week prior to the operation.

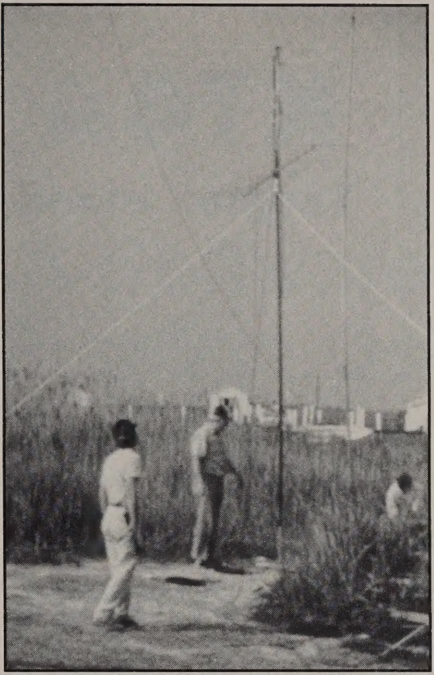
We called ARRL and asked for their help in identifying foreign ham publications. The League sent a list of IARU member societies, and a separate list of IARU societies that have publications. Using these lists, we sent press releases to 33 foreign ham publications. We have no way of knowing how many of those 33 releases were published, but when we were on Tangier Island, many European hams told us they saw our announcement in their countries' ham magazines, so we know the campaign was fruitful.

By promoting and publicizing like crazy, we whipped up considerable interest in the KT4A operation -- even though it was only another station in Virginia!

Accommodations

We made telephone arrangements with the Mayor of Tangier to rent the Island's community center for five days. The center consisted of a large building with a gymnasium and an adjoining kitchen that held the large tables that we used for our operating positions.

We made reservations at Hilda Crockett's Hotel and Restaurant for lodging and meals for the ten hams making the trip -- N3EHD, W3GIS, K3KMO, KC3NG, KA3OVK, KA3PGL (now KD3IY), K3UBI, W3XO, N5GQD, and W9GC.



Some of the antennas, almost finished; from left: W9GC, W3X0, and KA3OVK.

The community center rental was $35 per day. The hotel rooms, including two home-cooked all-you-can-eat meals a day, went for $26 a day. We had truly Left Civilization Behind.

Let's Go!

The group traveled to Tangier Island via several means. KA3PGL and KC3NG flew there in a private plane. N5GQD drove down to the Virginia shore on the Chesapeake Bay and chartered a plane to fly over. The rest of the gang drove across the Chesapeake Bay Bridge and down to Crisfield, Maryland, to catch the daily mail boat over to the island.

The island is isolated enough to make it necessary to plan for any eventuality -- just like a real DXpedition. We took everything we expected to need, including antennas, ropes, guy stakes, masts, coax, rigs, repair equipment and tools, fuses, etc. Our HF equipment consisted of a Kenwood TS-930, TS-530 , and TS-430, and a Ten-Tec Century 22. A TS-600 and 100 W amp was used on 6 meter SSB, and a TS-751A and 200 W amp on 2 meter FM and SSB.

Dipoles were put up for each HF band, 11 elements for 2 meter FM, 4 elements for 2 meter SSB, and 3 elements for 6 meter.

On the Air

"CQ CQ; this is KT4A, Tangier Island; over." We could say that a few times and create a pile-up. Many hams wanted to contact us because of the Islands on the Air (IOTA) award sponsored by the Radio Society of Great Britain. Some wanted to work us because of our Special Events announcement in *QST*. Others didn't know where we were but figured they better work us because we might

The TS-930S operating position being shown to Tangier residents who came to visit; from left: KA3PGL/KD3IY, K3KM0, four visitors, and N3EHD.

be some weird kind of rare DX.

Some hams asked where we were, and we truthfully gave our latitude and longitude. One ham called again in a few minutes and said, "Why, yure in Ver-gin-yuh!" We agreed and went right on working the others in the pile-up, who didn't care where we were but were enjoying the excitement of the chase.

We operated from May 14 to 18, 1987, staying on the air each night until we had worked everyone we could hear (typically at about 0500 local time), and then starting again a few hours later as band conditions changed. Even though radio conditions were not very good, we made 2,040 contacts with stations in 47 states and 60 countries. Our QSO rate often reached 60 or 70 per minute, even with the poor conditions we experienced. And we even worked KT4A at home!

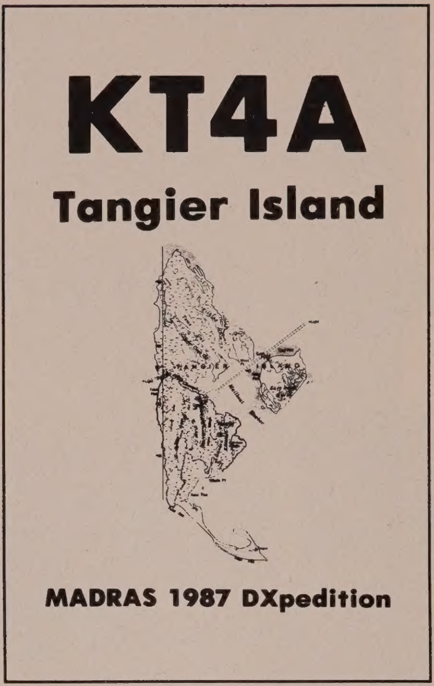
N3COB, back in the DC area, very kindly ran phone patches for us to our wives, and the stations in the pile-ups were very courteous in standing by for our "overseas" patches to the folks back home.

Back Home

We were dog-tired when we left Tangier Island, but very pleased with the results. By the time we got home, the first 25 QSL's (with SASE's) were in my mailbox. Two days later, 108 cards arrived in a single day's mail, many from DX stations and all with SASE's. Cards continued to trickle in for three years via the DX bureau. We replied to all QSL's received, although the backlog got so big that we were terribly behind for a while.

Moral

The morals of this story are twofold:



KT4A

Tangier Island

MADRAS 1987 DXpedition

The KT4A QSL card, in the true spirit of DXpedition cards, is an impressive addition to the wall of any shack.

(1) If you publicize heavily, and if you sound like a DXpedition and act like a DXpedition, you can generate the atmosphere that results in a lot of good operating time, both for you and the hams trying to work you.

(2) Ham radio can be a lot of fun, if you don't get too serious.

Al Brogdon's QTH is P.O. Box 60, Damascus, MD 20872. Nowadays he operates 100 percent CW and 100 percent mobile, and has currently worked 141 countries with his mobile 20-watt Century 22 and six mono-band whips.

Other MADRAS members participating in this DXpedition were: N3EHD, Alan Fener, Silver Spring, MD; W3GIS, Ron Fineman, Rockville, MD; KC3NG, Renee Culver, now of Milford, NH; KA30VK, Jon Albers, Bethesda, MD; KA3PGL (now KD3IY), Terry Hoption, Derwood, MD; W3X0, Bill Tynan, Silver Spring, MD; N5GQD, Gary Shipley, Rockville, MD; and W9GC, Gary Chatters, College Park, MD.

Post-MADRAS harvest time at the Tangier Island, Virginia, "Hydroponic Antenna Farm". (Photo courtesy of the Virginia Division of Tourism)

A Software Code Practice Oscillator

by Ellen Atack

Here is a simple program for hams and hams-to-be (like myself) to practice their code recognition or improve their speed. It was written in IBM BASIC for the IBM PC (if you have a more sophisticated BASIC interpreter such as Microsoft® QuickBASIC, you can write yourself a zippier version without ugly GOTOs and such).

Learning International Morse Code

Complete novices should begin by getting used to the sound of each letter and number at around 5 words per minute. Type each letter and number until you can recognize them. Once you have mastered A-Z and 1-0, you can make up some practice files with simple words and punctuation marks. If possible, do not echo the contents of a file to the screen; write what you hear, then compare your copy with the contents of the file. Above all, don't panic if you miss a letter or two -- missing one letter in a message is better than missing the whole thing!

How to Use CW.BAS

Load the program into your BASIC interpreter, and run it. You will be prompted for the "desired code speed." You can choose from a minimum speed of

```
10  ’CW.BAS -- A SMALL CODE PRACTICE PROGRAM
20  ’
30  ’SET CODE SPEED
40  CLS
50  INPUT "DESIRED CODE SPEED IN WORDS PER MINUTE
    (VALID RANGE 3-25) : ",SPEED
60  TEMPO% = 10 * SPEED
70  ’TEMPO% must be an integer between 32 and 255
80  IF TEMPO% < 32 THEN TEMPO% = 32
90  IF TEMPO% > 255 THEN TEMPO%= 255
100 ’
110 ’DEFINE DOTS, DASHES, LETTER & WORD SPACE
120 DIT$ = "ML T" + STR$(TEMPO%) + " P20 L20 C"
130 DAH$ = "ML T" + STR$(TEMPO%) + " P20 L20 CCC"
140 LSPACE$ = "ML T" + STR$(TEMPO%) + "P10"
150 WSPACE$ = LSPACE$ + LSPACE$ + LSPACE$
200 ’
210 ’DEFINE CODES FOR LETTERS AND NUMBERS
220 DIM MORSECODE$(90)
230 MORSECODE$(ASC(" ")) = WSPACE$
240 MORSECODE$(ASC("A")) = LSPACE$ + DIT$ + DAH$
250 MORSECODE$(ASC("B")) = LSPACE$ + DAH$ + DIT$ +
    DIT$ + DIT$
260 MORSECODE$(ASC("C")) = LSPACE$ + DAH$ + DIT$ +
    DAH$ + DIT$
270 MORSECODE$(ASC("D")) = LSPACE$ + DAH$ + DIT$ +
    DIT$
280 MORSECODE$(ASC("E")) = LSPACE$ + DIT$
290 MORSECODE$(ASC("F")) = LSPACE$ + DIT$ + DIT$ +
    DAH$ + DIT$
300 MORSECODE$(ASC("G")) = LSPACE$ + DAH$ + DAH$ +
    DIT$
310 MORSECODE$(ASC("H")) = LSPACE$ + DIT$ + DIT$ +
    DIT$ + DIT$
320 MORSECODE$(ASC("I")) = LSPACE$ + DIT$ + DIT$
330 MORSECODE$(ASC("J")) = LSPACE$ + DIT$ + DAH$ +
DAH$
340 MORSECODE$(ASC("K")) = LSPACE$ + DAH$ + DIT$ +
    DAH$
350 MORSECODE$(ASC("L")) = LSPACE$ + DIT$ + DAH$ +
    DIT$ + DIT$
```

three words per minute to a maximum speed of twenty-five words per minute. This range should suit both the beginner and expert since the U.S. Novice Class (least experienced) and Extra Class license (most experienced) require code proficiency of five and twenty w.p.m., respectively.

You will then be asked if you want to transmit code from a file. Answer "Y" (yes) if you have a practice ASCII file and "N" (no) if you want to type in the letters and numbers from your keyboard.

Next you will be asked if you want the code echoed to the screen. If you choose this option, letters and numbers will be displayed on the screen one at a time as the corresponding sound is made.

The computer will then transmit Morse code until the enter key is hit (if you are "keying" from the keyboard) or the end of the file is reached (if transmitting from an ASCII file).

How CW.BAS Works

The program uses the BASIC "PLAY" statement to make the sound of a dit or dah. For example, a "dit" is defined by the string "ML Tx P20 L20 C". "ML" stands for music legato; each note plays for a full period set by the note length (the default is "MN" or music normal in which a note will only play for 7/8 of its length). "Tx" is the tempo, where x is the number of 1/4 notes in a minute. "P20" is a 1/20th note length pause and "L20" is a 1/20th note. Finally, "C" is the note to be played.

A unit pulse is defined to be 1/20th note duration, so a dit, which is two unit pulses long, is equivalent to a 1/10th note. The transmission speed in words per minute is calculated by dividing the number of dits per minute by 25. The number of dits per minute can be calculated from the tempo by:

```
360 MORSECODE$(ASC("M")) = LSPACE$ + DAH$ + DAH$
370 MORSECODE$(ASC("N")) = LSPACE$ + DAH$ + DIT$
380 MORSECODE$(ASC("O")) = LSPACE$ + DAH$ + DAH$ +
    DAH$
380 MORSECODE$(ASC("O")) = LSPACE$ + DAH$ + DAH$ +
    DAH$
390 MORSECODE$(ASC("P")) = LSPACE$ + DIT$ + DAH$ +
    DAH$ + DIT$
400 MORSECODE$(ASC("Q")) = LSPACE$ + DAH$ + DAH$ +
    DIT$ + DAH$
410 MORSECODE$(ASC("R")) = LSPACE$ + DIT$ + DAH$ +
    DIT$
420 MORSECODE$(ASC("S")) = LSPACE$ + DIT$ + DIT$ +
    DIT$
430 MORSECODE$(ASC("T")) = LSPACE$ + DAH$
440 MORSECODE$(ASC("U")) = LSPACE$ + DIT$ + DIT$ +
    DAH$
450 MORSECODE$(ASC("V")) = LSPACE$ + DIT$ + DIT$ +
    DIT$ + DAH$
460 MORSECODE$(ASC("W")) = LSPACE$ + DIT$ + DAH$ +
    DAH$
470 MORSECODE$(ASC("X")) = LSPACE$ + DAH$ + DIT$ +
    DIT$ + DAH$
480 MORSECODE$(ASC("Y")) = LSPACE$ + DAH$ + DIT$ +
    DAH$ + DAH$
490 MORSECODE$(ASC("Z")) = LSPACE$ + DAH$ + DAH$ +
    DIT$ + DIT$
500 MORSECODE$(ASC("1")) = LSPACE$ + DIT$ + DAH$ +
    DAH$ + DAH$ + DAH$
510 MORSECODE$(ASC("2")) = LSPACE$ + DIT$ + DIT$ +
    DAH$ + DAH$ + DAH$
520 MORSECODE$(ASC("3")) = LSPACE$ + DIT$ + DIT$ +
    DIT$ + DAH$ + DAH$
530 MORSECODE$(ASC("4")) = LSPACE$ + DIT$ + DIT$ +
    DIT$ + DIT$ + DAH$
540 MORSECODE$(ASC("5")) = LSPACE$ + DIT$ + DIT$ +
    DIT$ + DIT$ + DIT$
550 MORSECODE$(ASC("6")) = LSPACE$ + DAH$ + DIT$ +
    DIT$ + DIT$ + DIT$
560 MORSECODE$(ASC("7")) = LSPACE$ + DAH$ + DAH$ +
    DIT$ + DIT$ + DIT$
570 MORSECODE$(ASC("8")) = LSPACE$ + DAH$ + DAH$ +
    DAH$ + DIT$ + DIT$
580 MORSECODE$(ASC("9")) = LSPACE$ + DAH$ + DAH$ +
    DAH$ + DAH$ + DIT$
590 MORSECODE$(ASC("0")) = LSPACE$ + DAH$ + DAH$ +
    DAH$ + DAH$ + DAH$
600 MORSECODE$(ASC(".")) = LSPACE$ + DIT$ + DAH$ +
    DIT$ + DAH$ + DIT$ + DAH$
610 MORSECODE$(ASC(",")) = LSPACE$ + DAH$ + DAH$ +
    DIT$ + DIT$ + DAH$ + DAH$
620 MORSECODE$(ASC("?")) = LSPACE$ + DIT$ + DIT$ +
    DAH$ + DAH$ + DIT$ + DIT$
630 MORSECODE$(ASC(":")) = LSPACE$ + DAH$ + DAH$ +
    DAH$ + DIT$ + DIT$ + DIT$
```

```
640  MORSECODE$(ASC(";")) = LSPACE$ + DAH$ + DIT$
     + DAH$ + DIT$ + DAH$ + DIT$
650  MORSECODE$(ASC("/")) = LSPACE$ + DAH$ + DIT$
     + DIT$ + DAH$ + DIT$
660  ENDOFMSG$ = LSPACE$ + DIT$ + DAH$ + DIT$ +
     DAH$ + DIT$
670  DOUBLEDASH$ = LSPACE$ + DAH$ + DIT$ + DIT$
     + DIT$ + DAH$
680  INVITETRANSMIT$ = MORSECODE$(ASC("K"))
700  '
710  'DETERMINE WHERE CODE TO BE TAKEN FROM
720  INPUT "Transmit code from a file (Y/N)? ", FILE$
730  IF FILE$ <> "Y" OR FILE$ <> "y" GOTO 900
740  'GET CODES FROM A FILE
750  INPUT "Name of file with codes : ", FILENAME$
760  OPEN FILENAME$ FOR INPUT AS #1
770  GETIT$=""
780  IF EOF(1) GOTO 790 ELSE GETIT$= GETIT$ +
     INPUT$(1,#1) : GOTO 780
790  INPUT "Echo code to screen (Y/N)? ", ECHO$
800  'BEGIN TRANSMISSION
810  FOR I = 1 TO LEN(GETIT$)
820    IF (MID$(GETIT$, I, 1) >= "a") AND
       (MID$(GETIT$,I,1) <= "z") THEN
         PLAY MORSECODE$(ASC(MID$(GETIT$,I,1)) - 32)
830    ELSE IF (MID$(GETIT$,I,1) > = " ") AND
       (MID$(GETIT$,I,1) <= "Z") THEN
         PLAY MORSECODE$(ASC(MID$(GETIT$,I,1)))
       ELSE PLAY DOUBLEDASH$
840    IF ECHO$ = "Y" OR ECHO$ = "y" THEN
         PRINT MID$(GETIT$,I,1);
850  NEXT I
860  PLAY WSPACE$ + ENDOFMSG$
870  END
880  '
900  'GET CODE FROM KEYBOARD
910  INPUT "Echo code to screen (Y/N)? ", ECHO$
920  PRINT "Begin typing code, hit return when finished" : PLAY
     INVITETRANSMIT$
930  'GET KEYSTROKE
940  GETIT$ = INKEY$
950  IF GETIT$ = "" GOTO 940 ELSE IF GETIT$ = CHR$(13)
     GOTO 1000
960  IF (GETIT$ > = "a") AND (GETIT$ <= "z") THEN
     PLAY MORSECODE$(ASC(GETIT$ - 32)
970  IF (GETIT$ > = " ") AND (GETIT$ <= "Z") THEN
     PLAY MORSECODE$(ASC(GETIT$))
980  IF ECHO$ = "Y" OR ECHO$ = "y" THEN
     PRINT GETIT$;
990  GOTO 940
1000 PLAY WSPACE$ + ENDOFMSG$
1010 END
```

number of dits/minute = Tempo × (number of unit pulses in a 1/4 note ÷ number of unit pulses in a dit). In our case, the w.p.m. = (Tempo × 5/2) ÷ 25. Therefore, the correct tempo given the desired words per minute is:

Tempo = (25 × w.p.m.) × 2/5
= 10 × w.p.m.

A "dah" is defined in a similar fashion with an initial unit-length pause and three unit-length notes being played : "ML Tx P20 L20 CCC". Notice that letter- and word-spaces are defined to be two and six unit-length pauses long respectively (instead of three and seven). The "missing" pause for each is the pause at the beginning of a dit or dah.

Each letter is mapped into an array of strings, "MORSECODE$", that contains the appropriate combination of dits and dahs for that letter. For example, the letter A is defined as the concatenation of a letterspace ("LSPACE$"), a dit ("DIT$") and a dah ("DAH$"). When a letter, number or punctuation mark is captured (from a file or the keyboard), the Morse code string for that character is played. Special codes such as end-of-message, invitation-to-transmit, and double-dash are also defined and used where appropriate.

If you have a software program that would be useful to hams or suggestions on programs you would like to see in future issues of BEAM, write :

BEAM -- Digital ROM
c/o Seven Mountains Scientific
P.O. Box 650
Boalsburg, PA 16827

Ellen Atack is a frostback in this country temporarily with her graduate student OM. Ellie is a computer scientist with a degree from Queen's University. She plans to be on 80 meters before Christmas. We're not sure which Christmas.

The EZ40 Receiver

by Rodney A. Kreuter, WA3ENK

It doesn't matter if the ink is still wet on your license or if the parchment that your first ticket was printed on is yellow and cracked, I'll bet that some time lately you've had an urge to build something. Not a digitally synthesized all-band transceiver or a computer from scratch or anything that complicated. Well, here is something simple -- a 40-meter direct conversion receiver that you won't have to take out a loan to build and should be able to get working in an evening or two.

The direct conversion receiver has been around a long time. Like much of technology, it comes into favor and passes out again on a regular basis. It operates by taking an RF signal and directly converting it to baseband (audio), unlike its more favored cousin, the superhet, which first converts to an intermediate frequency (IF) before detecting the signal.

What can you do with a direct conversion receiver? You can use it for CW and SSB signals and, if you're very careful, even AM signals. I say very careful because the oscillator in the receiver must be EXACTLY tuned to the AM signal or a squeal (commonly called a heterodyne) will result.

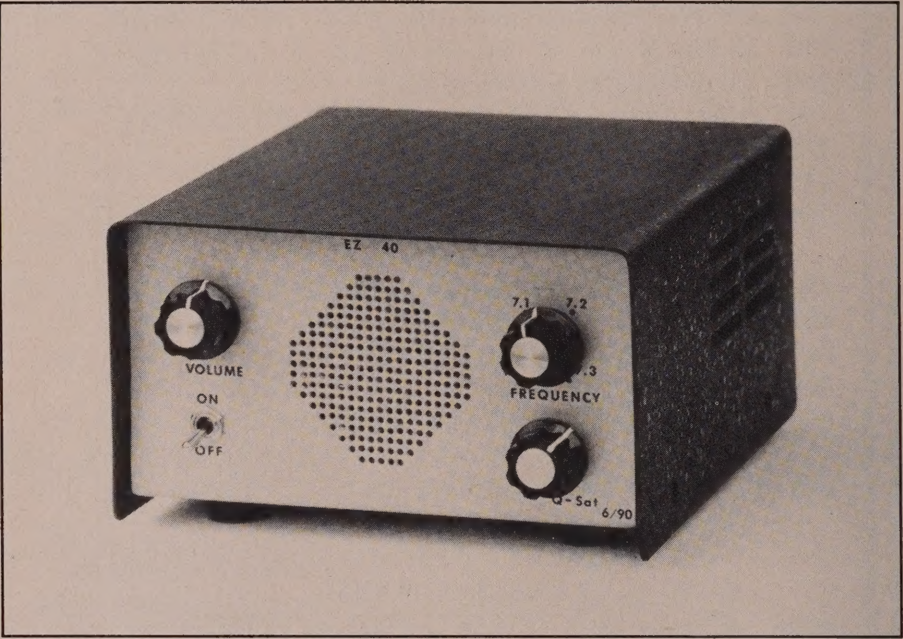


Figure 1. The EZ40 Receiver

Some History

Until recently, direct conversion receivers had three basic parts as shown in Figure 1: an oscillator, a mixer and an audio amplifier. Pretty basic, huh? There was a catch. Most mixers, of a few years ago, were passive. Simple diodes were commonly used and the signal that passed through them was not only not amplified, it was actually attenuated. Ordinarily only 10 to 20 percent of the signal got through (7 to 10 dB of attenuation). This loss could be made up by adding more gain after the mixer, and some used an RF amplifier ahead of the mixer in order to make up for the mixer's loss.

More gain after the mixer was where the direct conversion receiver got a bad name. Consider that a receiver has to have 100 dB of gain to amplify a 1 microvolt signal (a typical signal) to 100 millivolts (barely enough to drive an 8 ohm speaker). Add to this the 10 dB you lost in the mixer and you'll find that you have to build an audio amplifier with 110 dB of gain.

Building an audio amplifier with 110 dB of gain might seem easy at first, and it is easy on paper. Two op amps will do it. However, actually getting one to work that isn't microphonic and doesn't oscillate is no small task. It can be done, but then again so can building a computer from scratch (yes, including the operating system).

And forget operating this audio amplifier on AC. No amount of filtering is going to keep that 60 Hz hum out of your receiver. Most of the early direct conversion receivers had to be battery operated. I think they called them "B" batteries, or was that something else?

Now that I have you convinced that you don't want to have anything to do with a direct conversion receiver, technology comes to our rescue. Some of today's mixers are active Gilbert cell mixers. I won't go into how Gilbert cell mixers work because I don't know how they work, but they work well. Instead of 10 dB of loss, you get about 15 dB of gain. This means that you only have to build a 75 dB audio amplifier. One op amp would just about do it but it could not handle the current necessary to drive a speaker. A couple of transistors and an audio amp chip do the job just fine.

Now, about that Gilbert cell mixer. It seems that the folks at Signetics thought that a lot of people might have need of a mixer with a little gain and maybe an oscillator, so they developed the now famous NE602. In this 8-pin package is a double-balanced mixer and a oscillator which has become the tinkerer's second favorite chip, right after the 555 (also by Signetics, by the way).

Inside the EZ40

The EZ40 uses the same three basic functions that were shown in Figure 1. The oscillator and mixer functions are both performed by the NE602. All the rest is audio amplification and power supply.

Inductors L1 and L2 perform two functions. First L1 provides a resonant tank with C1 and C2. Next, the turns ratio of L1 to L2 provides a means of matching a 50 ohm antenna to the 3K (differential 1.5K) input of the NE602.

Inductor L3 along with its various capacitors tune the internal oscillator (or LO, local oscillator). Variable tuning is provided by means of D1, a varicap (or varactor), which is a variable capacitor when the diode is reverse biased. Conventional air variables are too hard to find and too expensive in this day of cheap silicon.

Basic Specification of the NE602

Power supply	4.5 to 8 Volts	
Current consumption	2.4 ma.	(typical)
Maximum mixer frequency	500 MHz	(typical)
Maximum oscillator Frequency	200 MHz	(typical)
Noise figure	5 dB	(typical at 45 MHz)
Mixer gain	15 dB	(typical at 45 MHz)
Third order intercept	-17 dBm	(maximum)
Mixer input resistance	1.5K	(typical)
Mixer input capacitance	3 pF	(typical)
Mixer output resistance	1.5K	(typical)
Mixer output capacitance	3 pF	(typical)

Table 1

Q1 and Q2 are configured as a simple audio amplifier. Note that they are preceded by a very simple RC low pass filter formed by R1 and C5. The combination of R1 plus the 1.5K internal resistance of the NE602 with the 0.01 μF capacitor provides a bandpass of about 3300 Hz. If you are more interested in CW, you may want to raise the value of R1 to 10K. This will lower the bandpass to about 1400 Hz. Feel free to insert a fancier audio filter between the volume control and the audio power amplifier.

The audio power amp, if a quarter of a watt can be called power, is provided by a Motorola chip, the MC34119. The 34119 has a lot going for it -- it's cheap and it works. If that isn't enough, it can operate from 2 volts to 16 volts, has a TTL compatible squelch

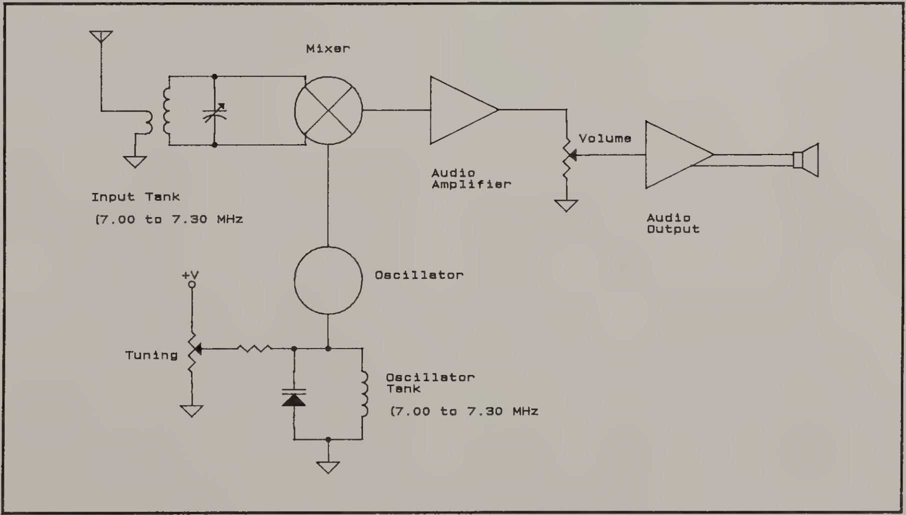
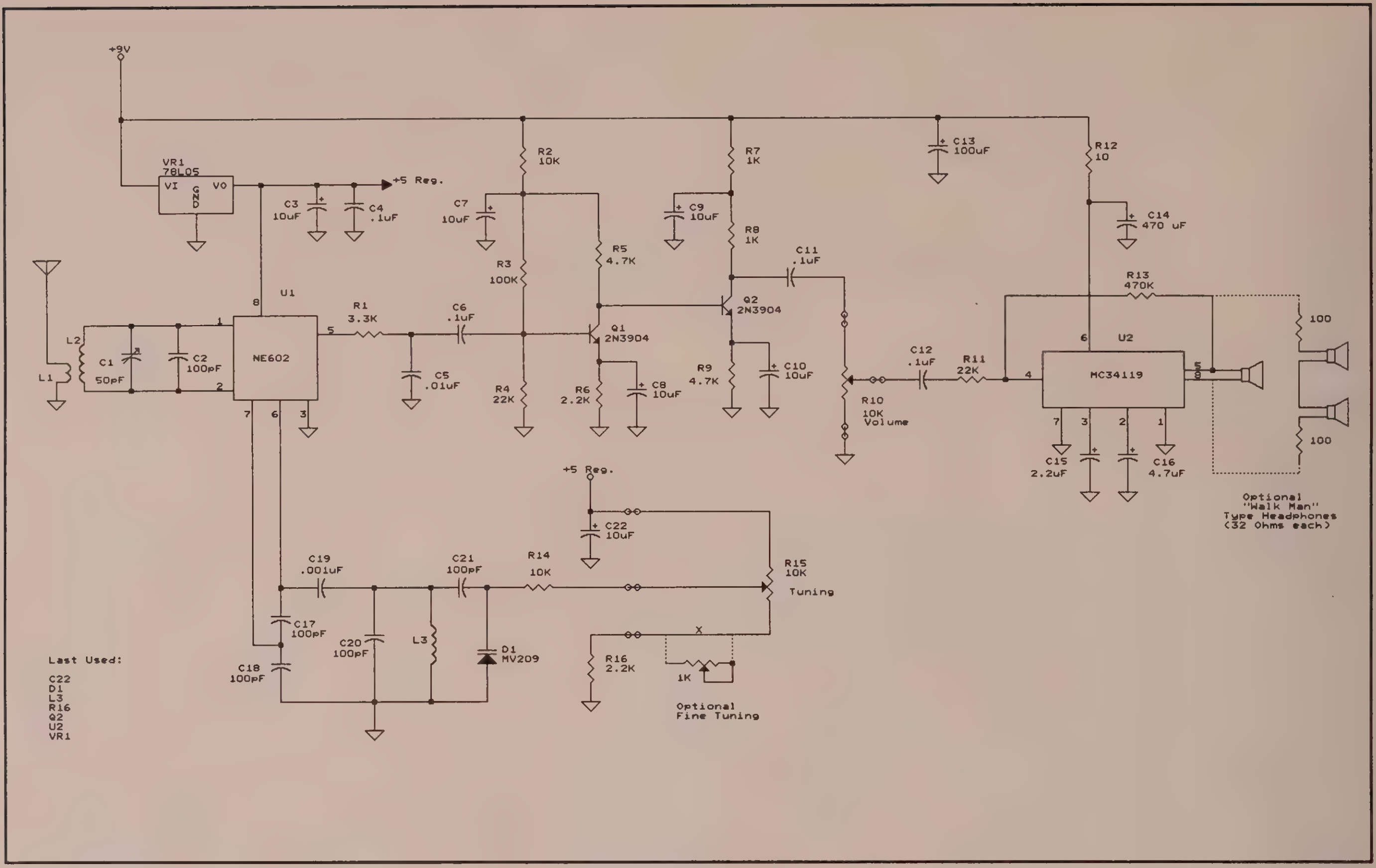


Figure 2. Block Diagram of EZ40 Receiver



Schematic Diagram of the EZ40 Receiver

input (pin 1) and doesn't require a large output coupling capacitor.

Construction

Even though this is a low frequency project, I highly recommend using the printed circuit board layout provided. It can certainly be built using point-to-point wiring or "dead bug" style layouts, but the time spent troubleshooting might make up for not making the board. Just a warning.

Inductors L1, L2, and L3 are wound on toriod cores. This makes them much smaller than air-wound coils but they can still be "tuned" a bit by stretching or compressing the wire on the toriods. Remember that a turn on a toriod is counted every time the wire passes through the inside of the core. After you get everything "just right," epoxy the coils in place on the boards.

Any speaker from 8 to 64 ohms will work with the MC34119. You probably have a couple in your junk box that will do just fine. Expect slightly less audio output with the higher impedance speakers. The leads to the speaker should be twisted tightly and kept short.

If you decide to use stereo headphones, don't connect the ground. Instead, just feed the speaker output through resistors (you may need to experiment with the value) to the left and right channels. Note that the MC34119 does not ground-reference the speaker.

There's never been a receiver made that can't use a good antenna, and this one is no exception. Although the first "field trials" were conducted in a state park with 30 feet of wire thrown over a tree limb, a good antenna will go a long way in improving reception. A dipole will give good results but if you're cramped for space you may want to try an active antenna. A ground also helps.

The receiver should be built into a metal cabinet to reduce the effects of hand capacitance. Although the prototype still hasn't made this transition, the effects are somewhat annoying.

Modifications

The basic design of the EZ40 can be adapted to almost any band. The only changes are L1, L2, L3, C2 and C19. Large changes in frequency will also require changing C16 and C17. Operation above 20 meters might be a bit tricky -- it's hard to build a stable VFO at high frequencies.

Now a word about C21. The varicap diode used in this receiver only needs to provide a change in capacitance of about 10 pF to cover 7.00 to 7.30 MHz. This can be from 20 to 30 pF or 0 to 10 pF or any combination that gives a change of 10 pF. When the bias voltage is changed from 1 to 5 volts, the capacitance really changes from about 40 pF to 20 pF. This much change would tune much more than the 300 kHz necessary to cover 40 meters. The series capacitor C21 restricts this tuning range. If you would like a greater range (and trickier tuning) you could make C21 larger, say 1000 pF. If you want to cover only the CW portion of 40, for example, you could make C21 smaller, say 20 pF. In this manner you can expand or contract the tuning range. Of course, be prepared to play with the turns on L3. One hint, always wind more turns than you think you will need. It's easier to take off a turn at a time than to wire a new coil every time.

Tuning 300 kHz with a single turn pot can be tricky. A large knob seems to help. A ten-turn pot would be nice but is very expensive. A "poor man's ten-turn" can be made by putting a smaller (1K) pot in series with the normal 10K pot. This knob becomes the fine tuning. Be careful with the leads going to the tuning pot. Any AC signal on this voltage will modulate the oscillator with disastrous results.

The value of the tuning control isn't critical. Anything from 1K to 100K should work. If you change from the values given in the parts list, try and keep R16 about 20 percent of the tuning control. This keeps about 1 volt across the resistor and means that the tuning voltage varies from about 1 volt to 5 volts. Varicaps don't do much unless they have at least 1 volt of reverse bias.

The gain of this receiver is quite high. If you don't want to copy 0.2 microvolt signals and would like a little more margin of stability, you can reduce R8 to decrease the gain. With no QRM, signals of 0.2 microvolts were easily copied on the prototype.

Parts List for the EZ40 Receiver

1	C1	8-50pF trimmer
5	C2,C17,C18,C20,C21	100pF
6	C3,C7,C8,C9,C10,C22	10uF 16 volts or greater
4	C4,C6,C11,C12	0.1uF
1	C5	0.01uF
1	C13	100uF 16 volts or greater
1	C14	470uF 16 volts or greater
1	C15	2.2uF 16 Volts or greater
1	C16	4.7uF 16 volts or greater
1	C19	0.001uF
1	D1	MV209 (Motorola)
1	L1	28 Turns #28 on T-32-2 core
1	L2	4 Turns #28 on L1
1	L3	24 Turns #28 on T-32-2 core
1	R1	3.3K
2	R2,R14	10K
1	R3	100K
2	R4,R11	22K
2	R5,R9	4.7K
2	R6,R16	2.2K
2	R7,R8	1K
1	R12	10 ohms
1	R13	470K
2	R10,R15	10K pot
2	Q1,Q2	2N3904
1	U1	NE602 (Signetics)
1	U2	MC34119 (Motorola)
1	VR1	78L05

Power for the EZ40 may be anything from 9 to 16 volts. Be careful of nine-volt batteries. Some instabilities in the prototype were traced to a nine-volt battery that was down to seven volts under load.

Calibration

Calibration can be done several different ways. The easiest is to listen to the EZ40's local oscillator on a calibrated receiver. Since the EZ40's IF is essentially zero, the frequency of the LO is the same as

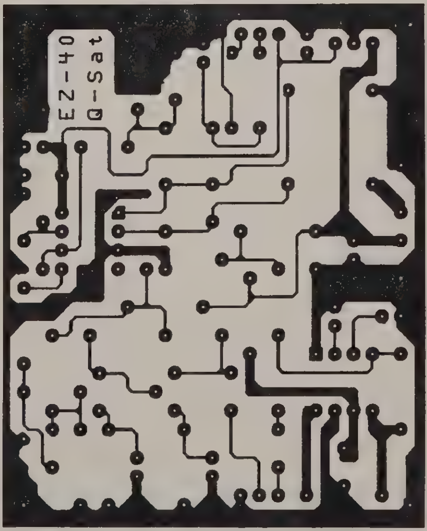


Figure 4. EZ40 Printed Circuit Board

the received frequency. Another method is to generate a frequency with a signal generator which has been connected to a frequency counter. The third method is to LOOSELY couple a frequency counter to pin 7 of the NE602.

Troubleshooting

Just in case you may have a problem, the following DC voltages should provide insight. All were taken with a digital voltmeter and a brand new alkaline nine-volt battery. Volume control was about one-third with no signal input.

	NE602	MC34119
Pin 1	1.28 v	0 v
Pin 2	1.28 v	4.18 v
Pin 3	0 v	4.14 v
Pin 4	3.68 v	4.02 v
Pin 5	3.59 v	4.16 v
Pin 6	5.04 v	9.12 v
Pin 7	4.62 v	0 v
Pin 8	5.10 v	4.22 v

	Q1	Q2
Emitter	0.52 v	4.60 v
Base	1.12 v	5.24 v
Collector	5.24 v	7.21 v

Rod Kreuter became interested in electronics at age 12, was WA3ENK at 14, and went on to a career in electrical engineering. He is currently a research engineer at Penn State University and owner of Q-SAT. Rod describes himself as a "hardware bum."

Parts kit (including shipping but not including pots, switches, connectors, speaker or case), EZ40-Kit, is available for $21; PC board only, EZ40-PCB, is $6, both from: Q-Sat, P.O. Box 110, Boalsburg, PA 16827. It takes Rod 3-5 weeks to get your order to you.

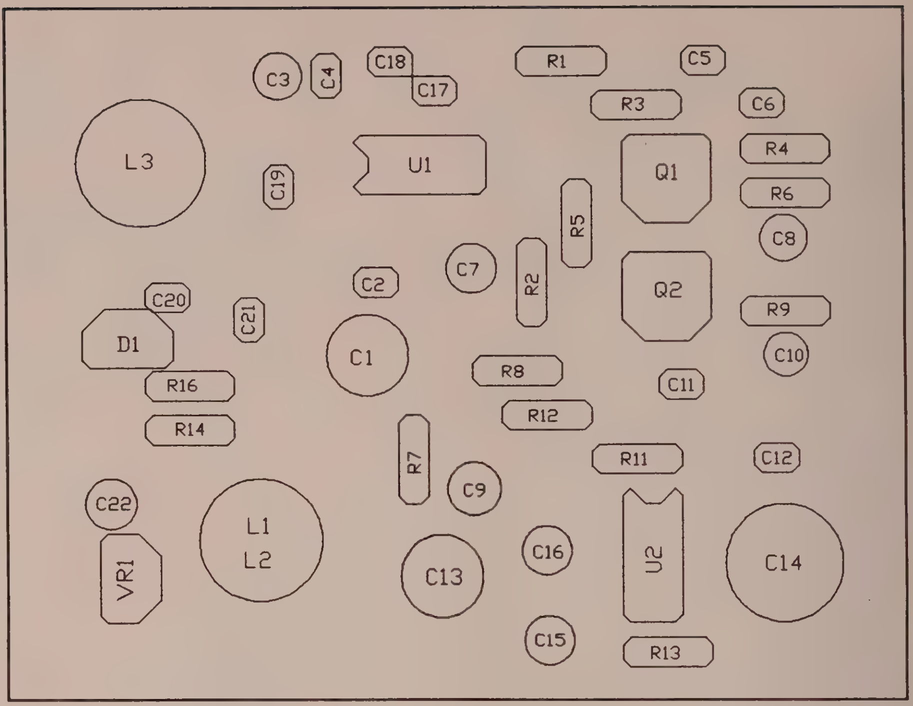
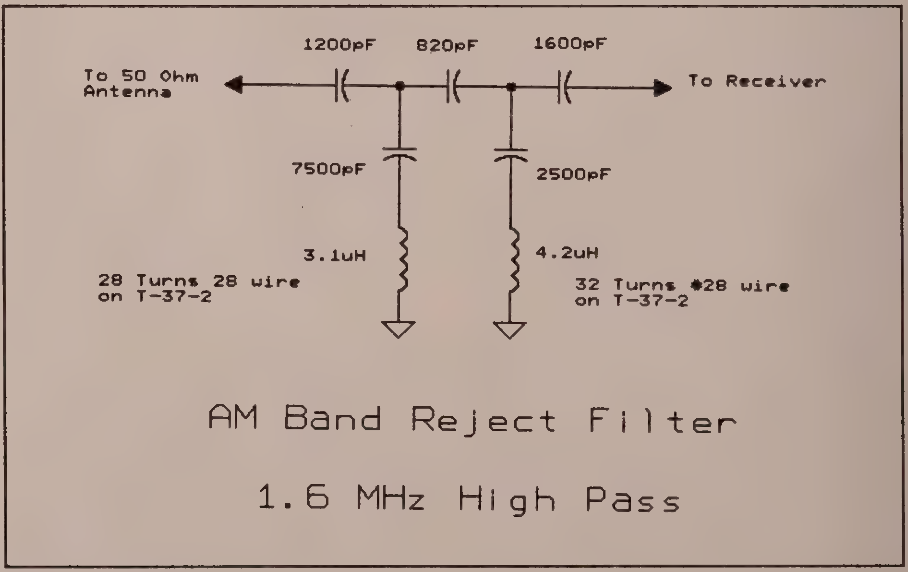


Figure 3. Parts placement

Editor's Note:

Our EZ40 receiver, when used with a 40 meter dipole 33 feet off the ground, was a bit too hot. We found that without a transmatch, intermodulation interference from local AM broadcast stations was strong enough to cause QRM in the receiver. Rod supplied us with a filter which attenuated these signals by about 40 dB. The schematic for the filter is included here in case you run into this problem.



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License Class: ☐ Extra ☐ Technician ☐ Advanced ☐ Novice ☐ General

2) ☐ Planning to obtain an amateur license

3) ☐ Short Wave Listener

4) ☐ Electronics Hobbyist

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D. What is your occupation? __________
____

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Type ______________________
____

F. When did you last buy communications gear?
____

G. What type of equipment do you own? (Check all that apply, then circle the one used most often.)

	Brand	Age
☐ Receiver		
☐ Transmitter		
☐ VHF/UHF hand-held		
☐ VHF/UHF transceiver		
☐ HF transceiver		
☐ Beam antenna		
☐ RF power amplifier		
☐ Computer		
☐ Mobile rig		
☐ Other		
☐ None at present		

H. Operating modes used: (Check all that apply, then circle the mode used most often).

☐ CW ☐ SSB ☐ Packet ☐ TV
☐ RTTY ☐ FM ☐ Satellite ☐ AM

I. Bands Used: (Check all that apply, then circle the band used most often).

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A. Are you: (check all that apply)

1) ☐ Amateur Radio Operator
Year first licensed ________ Call Sign ______

License Class:
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☐ Advanced
☐ General
☐ Technician
☐ Novice

2) ☐ Planning to obtain an amateur license

3) ☐ Short Wave Listener

4) ☐ Electronics Hobbyist

B. How many other people in your household are interested in this same hobby? ____________

C. Do you work in the electronics industry?
☐ Yes ☐ No

D. What is your occupation? ____________

E. Are you planning to buy communications gear within the next year? ☐ Yes ☐ No
Type ______________________

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____

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	Brand	Age
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☐ Transmitter	________	____
☐ VHF/UHF hand-held	________	____
☐ VHF/UHF transceiver	________	____
☐ HF transceiver	________	____
☐ Beam antenna	________	____
☐ RF power amplifier	________	____
☐ Computer	________	____
☐ Mobile rig	________	____
☐ Other	________	____
☐ None at present		

H. Operating modes used: (Check all that apply, then circle the mode used most often).

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☐ 30-300 MHz
☐ 300 MHz and up

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PRODUCT NEWS

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Military Affiliate Radio Systems and Civil Air Patrol operators can obtain radio modification information, free, from Kenwood USA Corp. All that's required is a copy of your MARS or CAP permit.

Please note that although modification information is available elsewhere, its validity and accuracy are questionable. Use of such incorrect information will void the warranty and possibly damage the radio.

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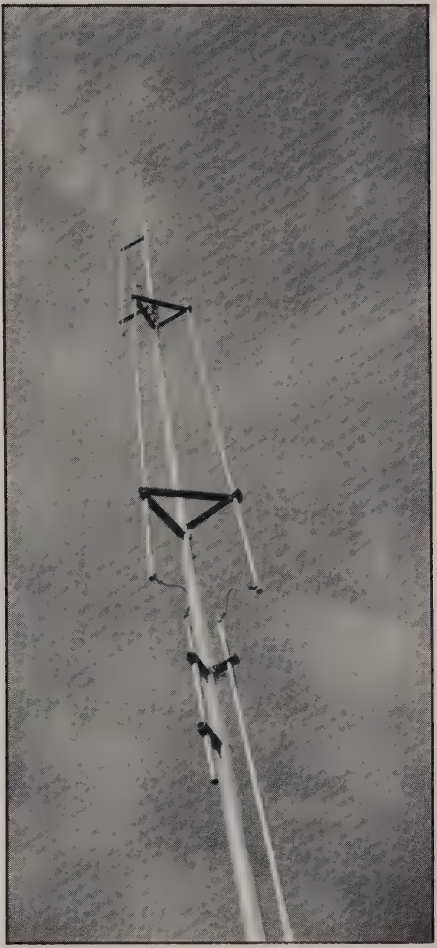
Multiband Antenna



GAP announces the introduction of its Challenger DX-VI, a unique multiband vertical antenna that launches RF 16 feet above the ground, well over most obstructions.

Developed by an aerospace engineer with 30 years experience in designing microwave systems and antennas for the government, the Challenger DX-VI provides total bandwidth less than 2:1 on 2m, 6m, 10m, 12m, 15m, 20m, and 40m. On 80m there is 140 kHz of bandwidth less than 2:1. There are no traps, coils, baluns, resistors, transformers or base insulators to steal RF power. Always active on every band, the antenna is pretuned, and no adjustments are necessary.

The Challenger DX-VI, with virtually no earth loss, eliminates the need for radials. Three 25-foot wires are necessary for 40m and 80m to create a counterpoise and can be arranged in virtually any fashion, making the antenna ideal for confined sites. Adding additional wires will not change performance.

Priced at $219, the Challenger DX-VI is constructed of high tensile strength aluminum and stainless steel, is self supporting and comes with a drop-in ground mount. All sections fully sleeve and are predrilled to insure ease of assembly and structural stability (no hose clamps).

Antenna height is 31.5 feet high; weight is only 18 pounds. Assembles in under 30 minutes using a supplied nut driver.

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High-Speed Multi-mode Data Controller

MFJ Enterprises, Inc. has released the new MFJ-1278T *Turbo*, amateur radio's first multi-mode data controller with a built-in high-speed 2400 baud modem.

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MFJ-1278T lets you transmit and receive Packet, Amtor, RTTY, ASCII, CW, FAX (including multi-gray level wire photos and weather maps), SSTV and Contest Memory Keyer. You also get Navtex reception.

Turbo also gives you, among other features, a printer port,a personal mailbox, precision tuning indicator, a KISS mode interface, fast through-put and anti-collision, independent transmit level adjustment for each radio port, lithium

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The new MFJ-1278T retails for only $359.95 and comes with MFJ's one-year unconditional guarantee. Or the new 2400 baud modem can be purchased separately for $79.95 and installed in any MFJ and most other TNCs.

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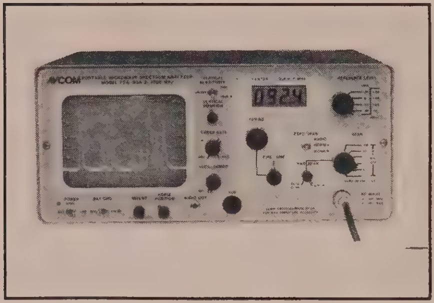

Portable Spectrum Analyzer

AVCOM introduces a new portable spectrum analyzer, model PSA-65A, that covers frequencies through 1000 MHz in one sweep with a sensitivity greater than -95 dBm at narrow spans. The lightweight, battery- or line-operated analyzer is the ideal instrument for two-way radio, cellular, cable, LAN, surveillance, educational, production, and R&D work.

Options include frequency extenders to enable the PSA-65A to be used at Satcom and higher frequencies, audio demod for monitoring, log periodic antennas, carrying case (AVSAC) and more. Size: 11-1/2w x 5-1/2h x 13-1/2d; Weight: 18 lbs./8.18Kg; Price: $2,855; Availability: stock.

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Handheld Universal Counter-Timer

Optoelectronics Inc. has a new universal counter-timer for frequency test and measurement -- Handi-counter Model-UTC 3000. Battery-powered and operating from sub-audio to microwave, it is claimed to be the smallest, lightest, most cost-effective such instrument on the market today.

It is designed for use in traditional laboratory benchtop service, as a frequency finder, and in a wide variety of field-service applications where two-way radio communication is important, including security, law enforcement and the military; broadcast media; electric utilities; ocean industries, airlines, mining, and cellular telephones.

UTC-3000 measures frequencies, periods, time intervals and ratios of frequencies. Applications include the identification of broadcast frequencies at maximum distance from the source; test and calibration of transmitter frequencies, medical equipment, oscillators and other types of electronic gear. It locates noise sources, serves as a signal strength indicator and satisfies hobby interests as well.

UTC-3000 weighs just 15 ounces and measures only 5.3 x 3.9 x 1.4 inches, yet it offers an ultra-wide dynamic range from 10 Hz to 2400 MHz, and is useful to 3200 MHz. The unit is housed in an extrusion case for maximum EMI/RFI shielding and rugged field use. No options are required to support the performance range.

Handi-counter Model UTC-3000 is priced at $375 complete. Optional TCXO is $80; three-antenna pack is $65; additional battery is $24; vinyl carrying case is $15. Availability of all items is quoted off-the-shelf.

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Amateur Radio vs The Microprocessor

by Daryl Gerke, K0FBF

First it was BCI, then RFI, and then TVI. Today we have a new problem -- MPI, or Micro Processor Interference. With the proliferation of the "computer on a chip" from automobiles to home computers to washing machines, MPI is inevitable.

This article not only discusses MPI, but it also provides some guidelines to predict, diagnose,and fix this problem.

The Source-Path-Victim Approach

When dealing with any interference problem, it is useful to break the problem into three pieces: the source, the path, and the victim. In this case the source is a nearby radio transmitter (amateur or otherwise), the path is electromagnetic radiation, and the victim is a computer- or microprocessor-controlled device.

Sources of MPI

In today's complex world, there are many potential radio transmitter sources. These include commercial radio and television, radar, microwave links, land mobile transmitters, and of course, amateur radio stations. With such complexity, a key question is which of these might constitute an actual threat to nearby computers.

At first glance, it would seem that the higher the power, the higher the threat. This suggests that handhelds would not be a problem, but that any commercial broadcast station would be a threat. But it's not the transmitter power, rather the power density of the electromagnetic field, that is the real issue here. Since field intensity decreases with distance, the nearby low power hand-held could be (and often is) a much bigger threat than the 100,000-watt transmitter down the road.

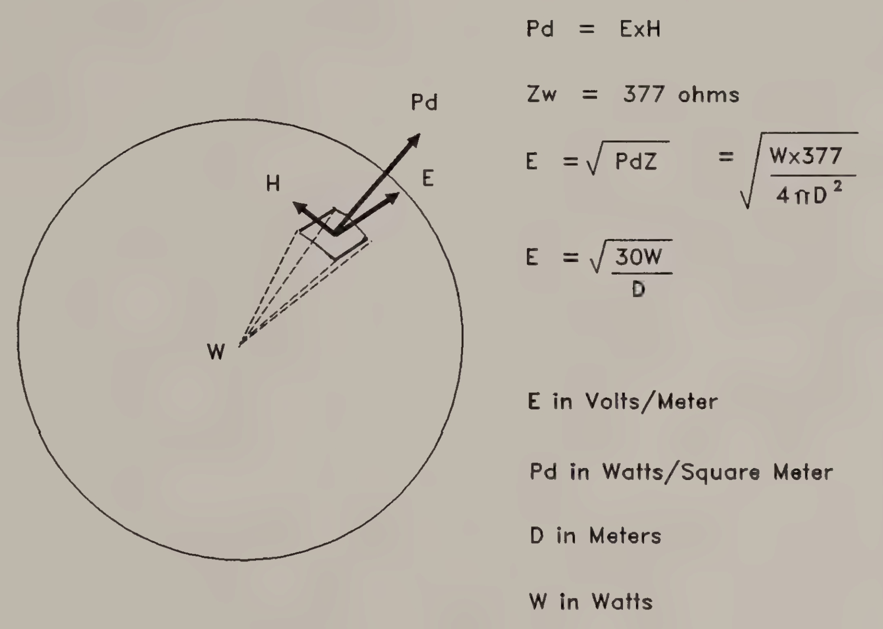


Figure 1: Electric Field as a function of Distance

Electric Field for Various Powers and Distances

	1 watt	10w	100w	1Kw	10Kw	100Kw
1 volt/meter	5.5m	17m	55m	170m	550m	1.7Km
5 volts/meter	1.1m	3.4m	11m	34m	110m	340m
10 volts/meter	55cm	1.7m	5.5m	17m	55m	170m

Predicting Problems

Most engineers agree that at electric field intensities of greater than 5 volts/meter, MPI problems are likely with today's computers. Fortunately, it is easy to make a quick "worst case" prediction for electric fields, based on the transmitter power, antenna gain, and distance from the antenna. Unfortunately, the resulting levels from nearby transmitters are often above the critical 5 volts/meter guidelines.

Figure 1 shows how this prediction is made, and gives some sample results, based on a formula which results from assuming a point source, no shielding, and far field conditions. For almost all cases we are concerned with, these are valid assumptions, and we get a worst case prediction of electric field intensity. Table 1 summarizes these field levels versus distance and power, and also gives three quick guidelines. It's pretty obvious from this data that low power transmitters, such as handheld or mobile units, can pose a serious threat to nearby computer systems.

Threat Levels

1 watt @ 1 meter = 5.5 v/m
30 watts @ 10 meters = 3 v/m
100 kwatts @ 1 km = 1.7 v/m

Table 1

For comparison, here are some typical specifications for electric field levels:

Military -- 1 to 200 volts/meter (the latter is topside of a ship, and is due to radar and HF transmitters)

Automotive -- 20-200 volts/meter (concerned about on-board and nearby land mobile transmitters)

Industrial -- 1-10 volts/meter (concerned about both handhelds and nearby commercial broadcast transmitters)

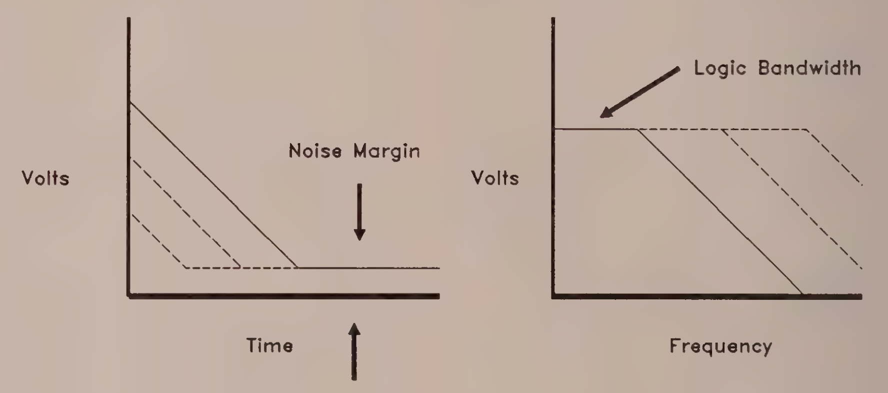
Local area networks -- 2-5 volts/meter (similar to industrial concerns)

Medical equipment -- depending on life-critical nature, up to 400 volts/meter

As hams, we are quite capable of approaching and even exceeding some of these levels with our equipment.

Computers as Victims

There are several failure modes and contributing factors for MPI. First, the cables and wiring often act as undesired antennas, carrying the RF energy into the computer system. Second, digital circuits and analog circuits have different failure modes that must be considered.



Typical Noise Margins — 400 mV

Typical Bandwidth — 30 to 300 MHz

Figure 2 -- Digital Circuit Characteristics

Cables as Antennas

All hams are well aware that at a length of 1/4 wavelength or more, any wire or cable will be effective as an antenna. But even shorter wires or cables can be quite effective in picking up MPI. For this reason, in the interference world, any wire or cable over 1/20 of a wavelength in length is considered an antenna. Table 2 shows these lengths for several popular amateur bands. That 3-foot printer cable on your PC can be a problem on 20 meters and higher, and at 2 meters even 3 or 4 inches can pose problems.

Cables as antennas

Key concern -- $L > \lambda/20$

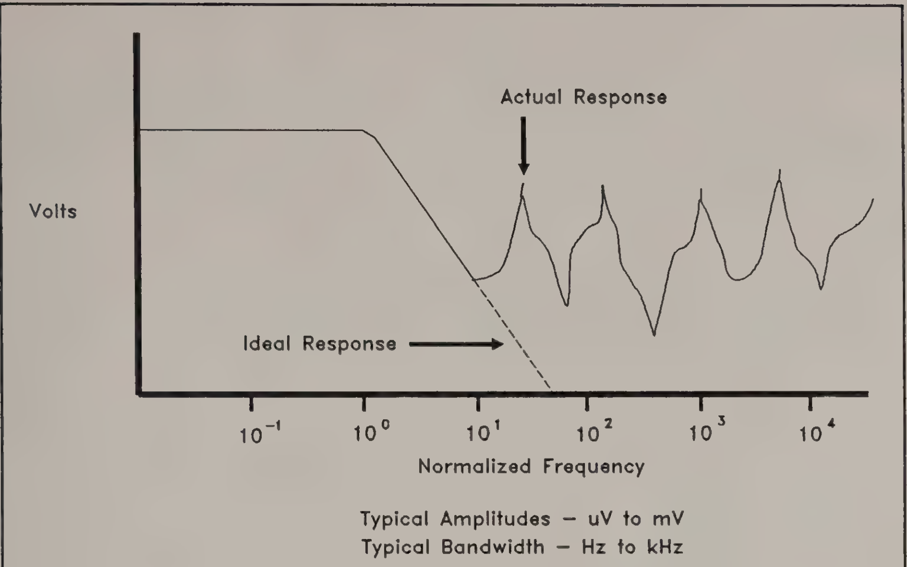
3.5 MHz = 13 Ft.
14.0 MHz = 3 Ft.
144 MHz = 4 In.
450 MHz = 2/3 In.

Table 2

Digital Circuit Failures

If that RF energy reaches a digital circuit, false triggering can occur. Most digital circuits today can respond to signals from DC to over 100 MHz, and as circuit speeds continue to increase, these frequencies increase as well. Voltages as low as 400 millivolts can cause upsets.

The "bandwidth" of a digital circuit is related to rise/fall times. A good approximation of this relationship is BW = 0.33/t. For example, at 10 nanoseconds, BW = 30 MHz, while at 1 nanosecond, BW = 300 MHz. Ten years ago, most



Typical Amplitudes – uV to mV
Typical Bandwidth – Hz to kHz

Figure 3

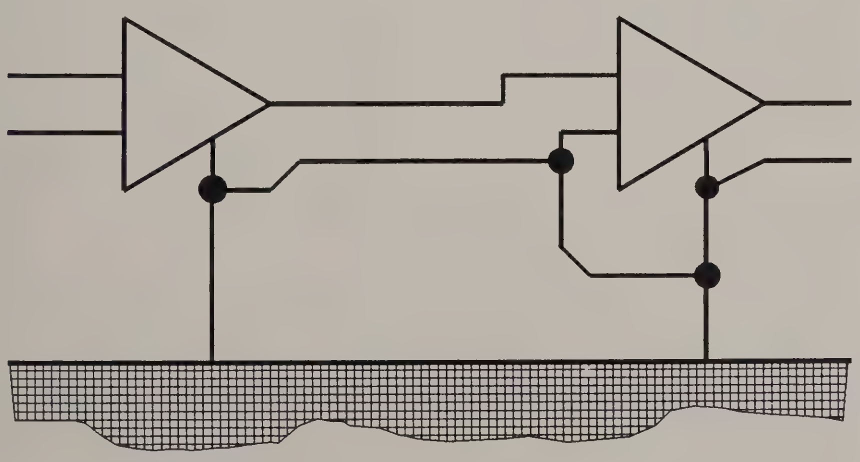
logic operated at 10 nanoseconds or more, so VHF signals were rejected by the circuits. Today, many of the common digital logic circuits operate at 1 to 3 nanoseconds, so the "window of susceptibility" has been opened to over 300 MHz. Unfortunately, the higher the frequency, the shorter the antenna (cable or wiring) needs to be. These digital circuit characteristics are shown in Figure 2.

Analog Circuit Failures

If the RF energy reaches an analog circuit, however, a different type of failure often occurs. In this case, the failure amplitudes are often magnitudes smaller, but the bandwidth is much less. One would expect the inherent high frequency rejection of a normally low frequency circuit to protect the analog victim.

Unfortunately, at about 100 to 1000 times the bandwidth of an analog circuit, parasitic capacitances and inductances can combine to cause resonances that greatly reduce this rejection. In addition, due to the low threshold levels, it is much easier to drive an analog circuit into saturation or cutoff, causing it to rectify the interference signal. Just like a simple detector, any modulation will be passed on to subsequent stages.

These analog circuit characteristics are shown in Figure 3. Incidentally, this is why a strong 10 meter (or 11 meter CB) signal can be heard in a stereo system, which theoretically should reject outside signals above 20 kHz.



Cable Fixes

- Reduce loop size & length
- Move cables
- Common mode chokes
- Ferrites
- Shield cables
- Twist wires

Figure 4

Fixing the Problems

Here are a few suggestions for preventing and fixing these problems. They are divided into three areas -- cables, box level, and system level.

At the **cable level**, efforts should be made to reduce the ability of the cables to pick up and deliver undesired energy into the system. Figure 4 shows a number of these fixes. Don't overlook shortening or moving cables; this very simple technique is often highly effective. Common mode chokes and ferrites can be effective too, since "common mode" pickup is usually larger than "differential mode" in these cases. Even four or five loops in a cable can be effective -- it's the same technique often used on a HF beam to keep energy off the coax shield.

At the **box level**, watch out for any shielding compromises. All lines entering and leaving an enclosure need filtering, such as ferrites or small capacitors (0.001 to 0.1 uf) decoupled to the cabinet. Any slots should also be sealed, and any susceptible cables or wiring should not be near any opening in the shield. Essentially, good transmitter and receiver shielding design techniques are called for.

At the **system level**, don't overlook some of the more simple fixes. Separate the equipment, if possible, since the electric field intensity decreases linearly with distance. Move the antenna, and pay attention to coax cable routing. Sure, it doesn't leak in theory, but in the real world, it causes problems. Consider separate power and grounding, since often these provide sneak paths for unwanted RF to couple into a computer system.

Some Case Histories

These problems are not confined to amateur radio. As consulting engineers, we frequently run into these problems. Here are several examples:

Finger-pointing engineer

In this case, a computer company field engineer wanted to blame an AM transmitter over a mile away for his computer's problems. (Hams aren't the only ones to be blamed because of their big antennas.) After contacting the station for the power figures, the quick prediction showed a worst case field of about 0.5 volts/meter. Since this is well below 5 volts/meter, and since the building probably provided some additional attenuation, we decided to concentrate on other areas. It was a power disturbance problem, not a radio problem.

Pooped-out pumper

In this case, a fire department had taken delivery of a new fire truck. After installing a high powered VHF communications radio, the microprocessor-controlled pumper would not work when the radio was transmitting. An investigation showed this to be an analog circuit failure. The analog pressure sensor was driven into rectification by the VHF transmitter. Additional shielding and filtering of the sensor was needed.

Concerned computer manager

In this case, the data processing manager for a company's critical transaction processing system was worried about moving to a new office building, since it was under 1/2 mile from a 50,000 watt FM broadcast antenna. Furthermore, the office was on an upper floor with lots of windows and almost directly level with the antenna. Due to the critical use of the computer, it was decided to shield the entire computer room, at an unexpected and unbudgeted cost of more than $100,000.

Summary

Computers and microprocessors are often quite susceptible to nearby RF fields. A typical guideline for failure is an electric field intensity of 5 volts/ meter (actual levels will vary.) Simple predictions can be made based on power, antenna gain, and distance from the antenna.

Failures occur since cables longer than 1/20 of a wavelength can act as good antennas. Digital and analog circuits fail for different reasons -- digital due to their high bandwidth, and analog due to low levels and rectification.

With a little bit of knowledge and some simple RF design methods, many of these problems can be prevented.

Daryl Gerke, KØFBF, is a registered professional engineer and a partner in Kimmel Gerke Associates Ltd., an electrical engineering consulting firm that specializes in solving interference problems. A dedicated ragchewer and DX chaser, he was first licensed in 1960, and holds an Advanced Class License and a First Class Commercial License. Daryl can be reached in St. Paul, Minnesota, at (612) 646-7715.

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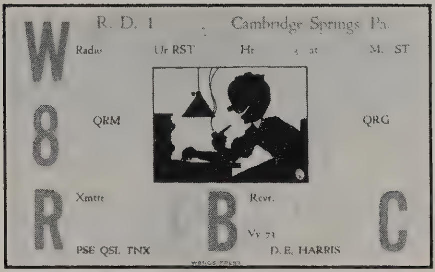
Reminiscences of an OM

by David E. Harris, W3ZX

One of the advantages of being a Senior Citizen (there aren't many) is being able to look "way back when" and dream about the past. I find myself indulging in that activity from time to time, especially with regard to enjoyable experiences related to amateur radio. Any unenjoyable one seems to have faded with the years.

I remember quite vividly my first QSO as a ham. It was in 1937, just after I got my first license. I had passed the 13 WPM code test "by the skin of my teeth," as the examiner remarked, and after a wait of about six weeks, the coveted ticket finally arrived with the call sign W8RBC (I lived in northwestern Pennsylvania near Meadville, and the western half of the state at that time was in the 8th call area -- it was changed to the 3rd just after World War II).

Imagine the agony of the moment. As a child of the Great Depression, I had just managed to buy a decent receiver only a few months earlier, but as yet had not accumulated enough funding to build a transmitter. In those days, the transceiver was an unknown entity -- receiver and transmitter were separate, the latter usually home-built. I had well-organized plans for my transmitter, but it was still on paper and I had accumulated only about half of the required parts.



W8RBC

R. D. 1 Cambridge Springs Pa.

Radio Ur RST Hr at M. ST

QRM QRG

Xmttr Revr.

Vy 73

PSE QSL TNX D. E. HARRIS

One day, while browsing through an electronics project handbook at a newsstand, I ran across an article for a simple one-tube transmitter circuit that appeared to require no parts that I didn't already have among my accumulated radio junk. So I squandered about 50 cents for the booklet and breathlessly dashed home to check my junk box for the needed parts. Eureka! All I lacked was some 1/4-inch copper tubing which I soon obtained from an auto supply store.

The circuit was called a Unity-Coupled Oscillator, and it used a type 45 vacuum tube which could probably develop around five watts as an oscillator. It was built on a breadboard (real wood), and had no panel -- who needs a panel! When completed, I could hear the signal in my receiver, and it was in the 40-meter band. However, when I moved my hand near the variable capacitor to adjust the frequency, the frequency would shift clear out of the band. That problem was resolved by adding a bar knob to the capacitor and adjusting the frequency by tapping the bar knob with a long pencil.

My antenna was a 40-meter Windom using a single wire feeder. The feed line clipped right onto the oscillator tank coil with a capacitor in series -- real high-class stuff!

The power supply was the best part of all. My family had an 11-inch tube Philco broadcast receiver in the living room. After my parents had retired for the night, I quietly moved the BC receiver into the shack and removed all of the tubes except the power supply rectifier. Using an old tube base, I made an adapter to plug into the Audio Power Amplifier socket to obtain filament and plate voltages for the transmitter. At last I was ready to try my hand as a ham.

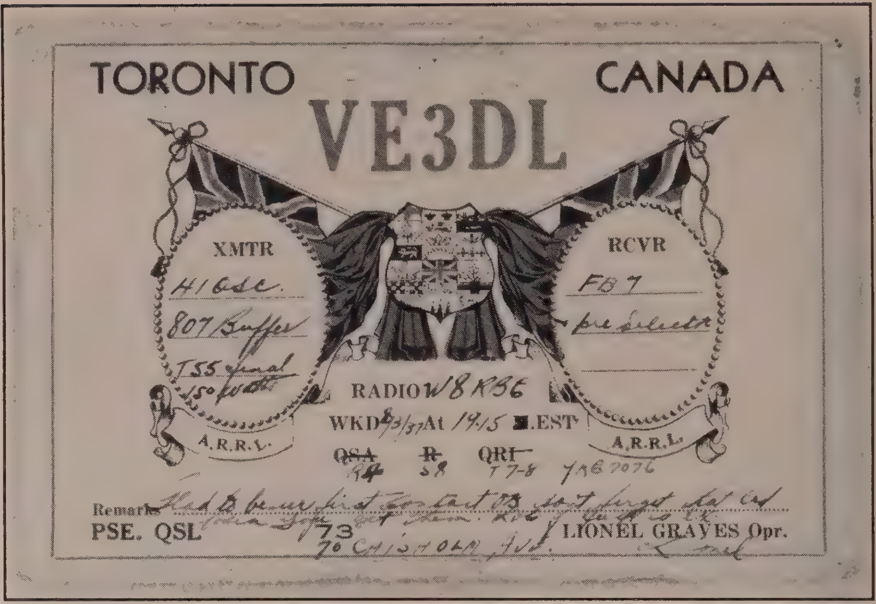
Carefully tuning around the lower end of the 40-meter band (the band was entirely CW at that time), I found VE3DL calling CQ. I carefully checked my transmitter frequency, pencil tapping it close to his, and nervously gave him a call. To my great surprise, he came right back and when he learned that it was my first QSO he was very gracious in putting up with my very nervous state. His QSL card (framed) still hangs on the wall of my shack.

All aglow, I considered that quite enough for one night, so I replaced the tubes in the BC receiver and returned it to the living room. That was the only contact that I ever made with that transmitter because after more rational thought I decided I had better not take a chance of getting an FCC Pink Slip by using that haywire setup.

Within a few months I was able to complete my first "real" transmitter which used a 6L6 crystal-controlled oscillator followed by push-pull 210's running about 100 watts input. The frequency was, of course, as stable as a rock. I had only one crystal, until after WWII, but that was no great handicap since hardly anyone else had more than one anyway.

The modern ham who has never operated anything but a transceiver may be interested to know that it was not ever thus. Before WWII the concept of the transceiver in ham radio was entirely absent. Even net operation on the same frequency was carried out with separate transmitters and receivers. If one wanted to participate in a net, he usually bought a transmitter crystal ground to the net frequency. The development of the modern transceiver came about as a logical result of the adoption of the use of Single Sideband. It was foolish to duplicate the expensive filters required by SSB when one could easily serve for both transmitting and receiving. It was logical, then, to also use a common oscillator to generate the transmit carrier frequency as well as the carrier reinsertion frequency for the receive mode, thus putting both input and output on the some frequency.

Operation with separate transmitter and receiver, especially if the transmitter used crystal control, was much different than it is today. Anyone wanting to make a contact could call CQ for an extended period, in order for someone scanning the band looking for a contact to find him. The operator answering a CQ would then similarly call the CQ'ing station for a long enough period for him to scan the frequencies around his calling frequency and find the answering station. Once the contact was made, of course, then communication proceeded much as it does now. It was not uncommon to hear someone calling CQ for a contact on another band, for example, a station on 40 meters calling CQ 80 meters.


TORONTO CANADA

VE3DL

XMTR
41osc.
807 Buffer
T55 final
150 watts

RCVR
FB7
pre Selector

A.R.R.L. A.R.R.L.

RADIO W8KBG

WKD 8/3/37 At 1415 .EST

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Remarks [illegible]

PSE. QSL 73

LIONEL GRAVES Opr.

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In the "good old days" you couldn't phone in your credit card number and order a beam antenna, or a tower or rotator antenna, for that matter. The HF enthusiast who used a directional antenna either constructed some sort of array of wire elements, or built a Yagi or similar rotatable array from whatever materials his ingenuity could muster. Mounting and rotating a beam antenna presented some real problems, and some of the contraptions that resulted were very interesting. Just after the war, thousands of prop-pitch motors appeared in the surplus ads, and many hams modified them for use as rotators. At the same time, synchro transmitters and receivers provided a solution to remote direction indication, but the "store-bought" tower had to wait until the needs of television resulted in the commercial development of fairly low-cost metal towers.

I think also there was a camaraderie among hams then that is seldom found today. It may have been due to the fact that getting on the air took a heck of a lot more doing than it does today. Or it may have been due to the fact that there are now more than ten times as many hams in the United States as there were in 1937. My first Callbook was about 5/8-inch thick and contained all the hams in the whole world. The U.S. had around 30,000 and the rest of the world probably 20,000 or less at that time. (The 1990 North American Callbook alone is 1 1/2-inches thick and contains 466,511 listings.)

A lot of water has passed over the dam since my contact with VE3DL, and he may have long since gone to meet his maker. But I still get a big thrill from being able to contact someone on 40-meter CW who has basically the same feeling for ham radio that I do.

Dave Harris, W3ZX, is a professional engineer who, after a distinguished career in electrical engineering, has turned his attention to being a full-time amateur radio operator and perfecting his image as a bon vivant.

The Venerable 807

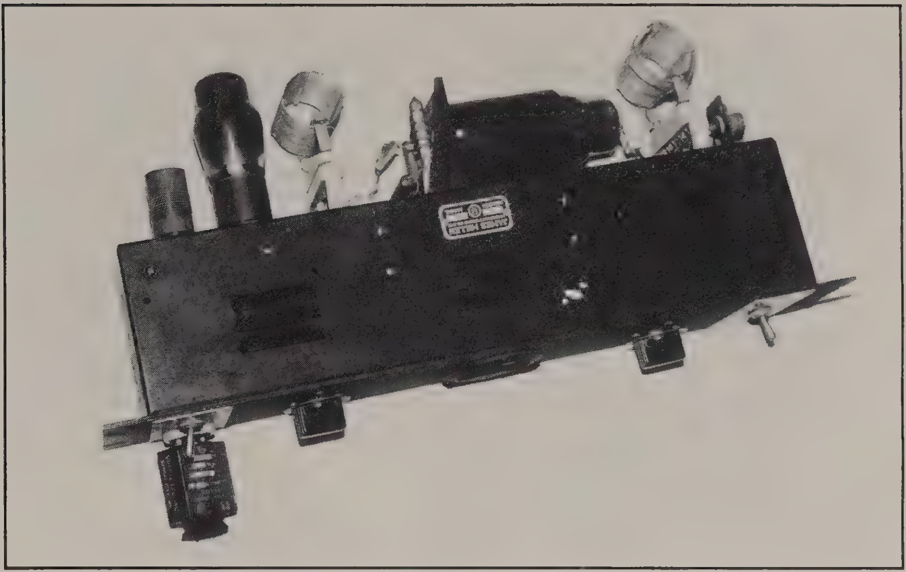
by Bud Volz, W3SMV

In several ways, 1936 was a pivotal year for amateur radio. It saw the passing of ARRL founding president Hiram Percy Maxim, as well as his vice president Charles Stewart; it saw amateur radio respond with competent emergency communications during the devastating March floods of that year; and it saw the introduction by RCA of a transmitting tube which would go on to become one of the all-time favorites among amateurs and commercial users alike -- the venerable 807.

With the introduction of the 807, and its receiving counterpart the 6L6 (later to be called 6L6G), RCA launched much more than just a wonderful vacuum tube; it launched an idea which would pervade power tube design for the rest of tube history -- the beam power amplifier -- or in more modern terms, the beam tetrode.

To understand the significance of the appearance of the 807, it is necessary to delve into some technical history from the ham's point of view.

In the mid '30s, hams seemed to be especially interested in transmitters which would cover many bands with crystal control, and perform well in A3 phone use. Because we were in the midst of a terrible economic depression, it was very important that costs be held way down -- hams had to make do with what could be scrounged and, in general, could afford little in the way of new parts or equipment. The most likely "bought" item in the ham shack was the receiver, with everything else being homemade or at least home-reworked.



A Millen Exciter using an 807 power amplifier and a 6L6GB oscillator.

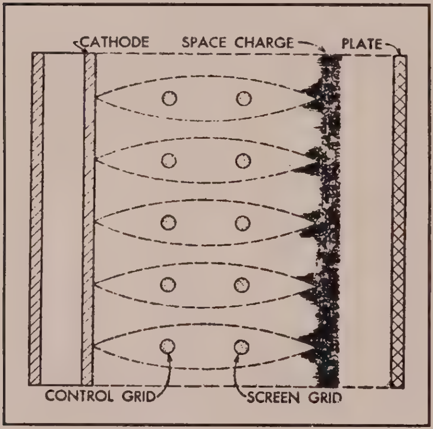
Without getting into a lot of detail about all this, what the ham needed for modern designs was a tube which would work well as both an amplifier and as a frequency multiplier, be stable without neutralization to facilitate frequency change and ease tuneup, need low driving power to minimize the number of stages in the rig, and develop some real power at reasonable low plate voltages -- again in the interest of economy and efficiency.

Though there were some good tube choices available -- the 802 pentode, for instance, introduced the year before was OK at low power -- they all fell down somewhere on the list. The stage was clearly set for the emergence of the tube (and tube technology) to answer the hams' prayer. What we got was a landmark tube (and idea). We could hardly have asked for better.

In the following year the 807 would take over as the clear amateur favorite in all the ham literature. It just seemed to do everything right! It answered the needs we mentioned, even worked at 2-1/2 meters, the 112 MHz band we had then. It was cheap, relatively, at about $3.50 each. It had an Isolantite (ceramic) base for low losses, and two other characteristics of which we would hear much more in time to come: high power sensitivity (low drive power) and high purveyance (good power at lower plate supply voltages).

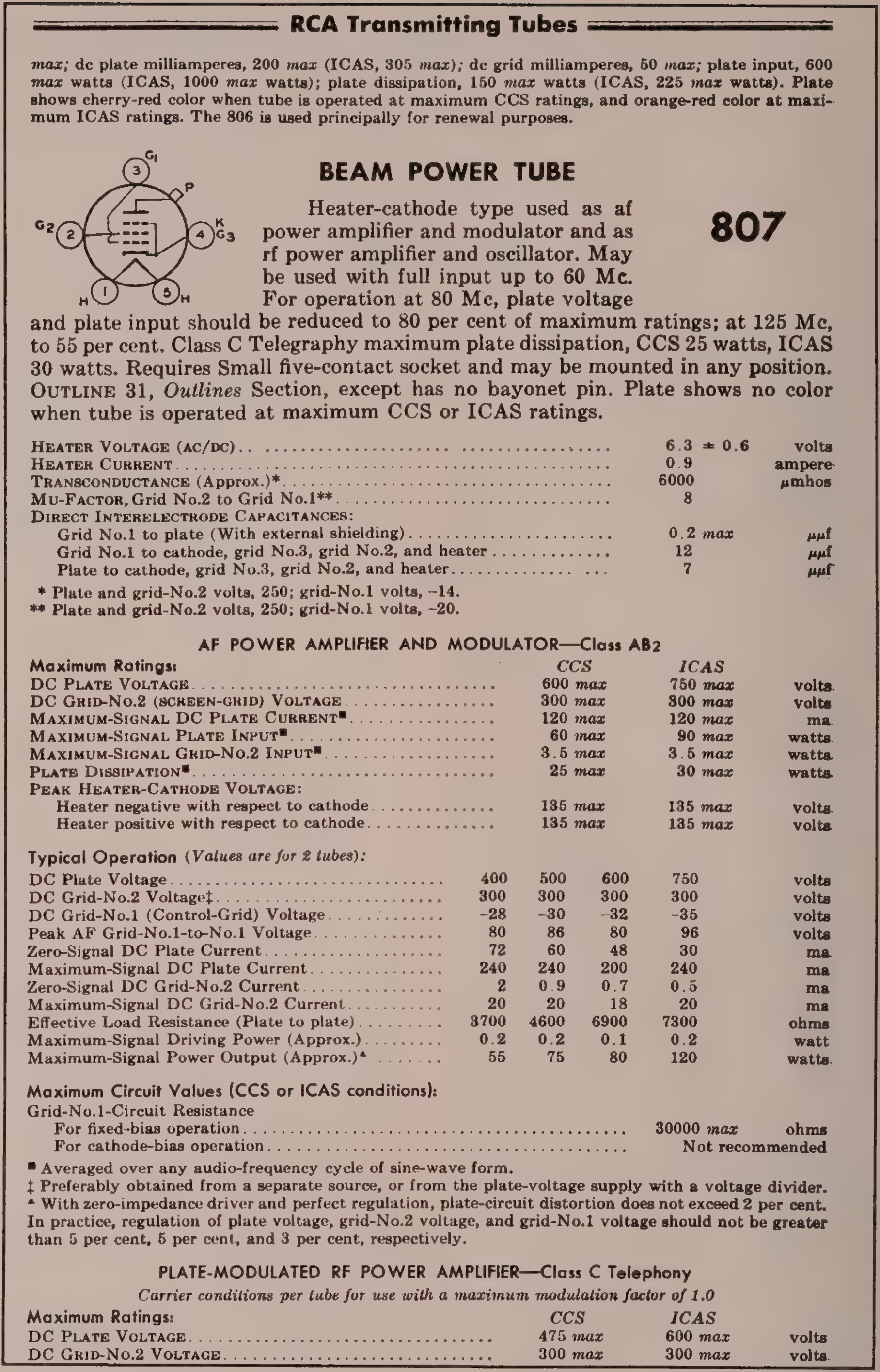
The turn had been made; the beam tetrode took off. The 807 and 6L6 began the progression which by the end of 1938 saw the introduction of other winning types which would soon help see us through the war: the 814 and 813 transmitting types and the 6V6 for receivers. The older tetrodes, fraught with secondary emission grief, and earlier pentodes with their complexity largely fell into disuse and obsolescence. The commercial designers took notice too and the beam power amplifier became as close to an instant hit as anything we ever seem to see.

Here we are 54 years later. So many tube types have come and gone; in fact, vacuum tubes have pretty much just gone. To me it is interesting to notice that among the handful of still readily available tube types for replacement use are the 807, 6L6(GC), the 6146 (another landmark introduced about 1950 as a natural successor to the 807) and the 813. It will be interesting to see when the last vacuum tube on earth is tipped-off and sealed, if it might just possibly be . . .



807 - Beam power tube. Grid Geometry

Carl "Bud" Volz, W3SMV is an electronics designer at Penn State University and lives in the woods near Potters Mills, PA. A life member of the ARRL and the Quarter Century Wireless Association, Bud can send and receive CW faster than most of us can talk.


G1
P
K
G3
G2
H
H
1
2
3
4
5

RCA Transmitting Tubes

max; dc plate milliamperes, 200 *max* (ICAS, 305 *max*); dc grid milliamperes, 50 *max;* plate input, 600 *max* watts (ICAS, 1000 *max* watts); plate dissipation, 150 *max* watts (ICAS, 225 *max* watts). Plate shows cherry-red color when tube is operated at maximum CCS ratings, and orange-red color at maximum ICAS ratings. The 806 is used principally for renewal purposes.

BEAM POWER TUBE

807

Heater-cathode type used as af power amplifier and modulator and as rf power amplifier and oscillator. May be used with full input up to 60 Mc. For operation at 80 Mc, plate voltage and plate input should be reduced to 80 per cent of maximum ratings; at 125 Mc, to 55 per cent. Class C Telegraphy maximum plate dissipation, CCS 25 watts, ICAS 30 watts. Requires Small five-contact socket and may be mounted in any position. OUTLINE 31, *Outlines* Section, except has no bayonet pin. Plate shows no color when tube is operated at maximum CCS or ICAS ratings.

HEATER VOLTAGE (AC/DC)	6.3 ± 0.6	volts
HEATER CURRENT	0.9	ampere
TRANSCONDUCTANCE (Approx.)*	6000	µmhos
MU-FACTOR, Grid No.2 to Grid No.1**	8	
DIRECT INTERELECTRODE CAPACITANCES:		
Grid No.1 to plate (With external shielding)	0.2 *max*	µµf
Grid No.1 to cathode, grid No.3, grid No.2, and heater	12	µµf
Plate to cathode, grid No.3, grid No.2, and heater	7	µµf

* Plate and grid-No.2 volts, 250; grid-No.1 volts, –14.
** Plate and grid-No.2 volts, 250; grid-No.1 volts, –20.

AF POWER AMPLIFIER AND MODULATOR—Class AB2

Maximum Ratings:	*CCS*	*ICAS*	
DC PLATE VOLTAGE	600 *max*	750 *max*	volts
DC GRID-NO.2 (SCREEN-GRID) VOLTAGE	300 *max*	300 *max*	volts
MAXIMUM-SIGNAL DC PLATE CURRENT■	120 *max*	120 *max*	ma
MAXIMUM-SIGNAL PLATE INPUT■	60 *max*	90 *max*	watts
MAXIMUM-SIGNAL GRID-NO.2 INPUT■	3.5 *max*	3.5 *max*	watts
PLATE DISSIPATION■	25 *max*	30 *max*	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 *max*	135 *max*	volts
Heater positive with respect to cathode	135 *max*	135 *max*	volts

Typical Operation (*Values are for 2 tubes*):					
DC Plate Voltage	400	500	600	750	volts
DC Grid-No.2 Voltage‡	300	300	300	300	volts
DC Grid-No.1 (Control-Grid) Voltage	–28	–30	–32	–35	volts
Peak AF Grid-No.1-to-No.1 Voltage	80	86	80	96	volts
Zero-Signal DC Plate Current	72	60	48	30	ma
Maximum-Signal DC Plate Current	240	240	200	240	ma
Zero-Signal DC Grid-No.2 Current	2	0.9	0.7	0.5	ma
Maximum-Signal DC Grid-No.2 Current	20	20	18	20	ma
Effective Load Resistance (Plate to plate)	3700	4600	6900	7300	ohms
Maximum-Signal Driving Power (Approx.)	0.2	0.2	0.1	0.2	watt
Maximum-Signal Power Output (Approx.)▲	55	75	80	120	watts

Maximum Circuit Values (CCS or ICAS conditions):		
Grid-No.1-Circuit Resistance		
For fixed-bias operation	30000 *max*	ohms
For cathode-bias operation	Not recommended	

■ Averaged over any audio-frequency cycle of sine-wave form.
‡ Preferably obtained from a separate source, or from the plate-voltage supply with a voltage divider.
▲ With zero-impedance driver and perfect regulation, plate-circuit distortion does not exceed 2 per cent. In practice, regulation of plate voltage, grid-No.2 voltage, and grid-No.1 voltage should not be greater than 5 per cent, 5 per cent, and 3 per cent, respectively.

PLATE-MODULATED RF POWER AMPLIFIER—Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings:	*CCS*	*ICAS*	
DC PLATE VOLTAGE	475 *max*	600 *max*	volts
DC GRID-NO.2 VOLTAGE	300 *max*	300 *max*	volts

From the RCA Transmitting Tube Technical Manual TT-4, 1956.

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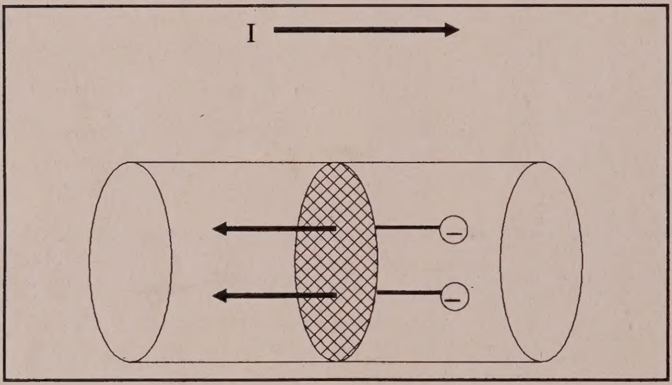
BACK TO BASICS

Electric Current

One of the most basic, although by no means simple, concepts in electronics is the idea of electrical current.

Current is a motion of charge through an area -- a flux. For example, consider the cross section of a wire -- a circular area. The current is the net flow of charge (say to the right) through this area per unit of time.

Charge in the MKS system of units is measured in Coulombs and time is measured in seconds. The current through this area is measured in Coulombs per second or Amperes (A). Small currents are more conveniently measured in milliamperes (mA) and microamperes (μA).



In a metal wire the primary charged particles which cross the area are conduction electrons which are negatively charged. One Ampere is flowing when 6.3 x 10^8 electrons cross the area in one second. The 60 watt light bulb in a lamp draws about one half of an ampere.

Two sorts of electric current are generally encountered in electronics -- Direct Current, DC, and Alternating Current, AC. Direct current flows in one direction only while alternating current flows back and forth through the area. Both sorts of current can be caused to flow by a force (called the electromotive force) which is measured in the MKS system in Volts, or Joules/ Coulomb.

Many of the important features of an electric current in a wire can be seen in a simple model. Consider a plastic water pipe slightly larger than a ping-pong ball and filled with ping-pong balls.

If you push one ball into the pipe at the left end then a different ball -- only one ball -- pops out of the right end. The ball pops out at about the same time that the other ball was pushed into the pipe. Actually it is delayed by at least 1 nanosecond for each foot of pipe -- the disturbance must propagate down the pipe slower than the velocity of light (3 x 10^8 meters/second).

Notice it takes force (you push) to move the balls through the tube. Now suppose we form the tube into a loop with a slot so that you can push the balls.

Notice:

1.) The balls stop if you stop pushing (friction -- resistance)

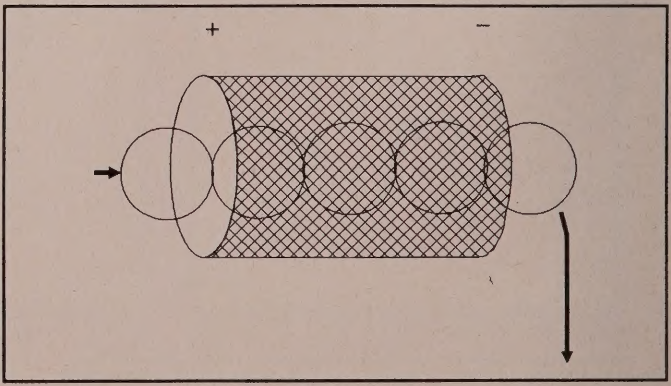
2.) While you are pushing the circuit is heated (friction -- resistance)

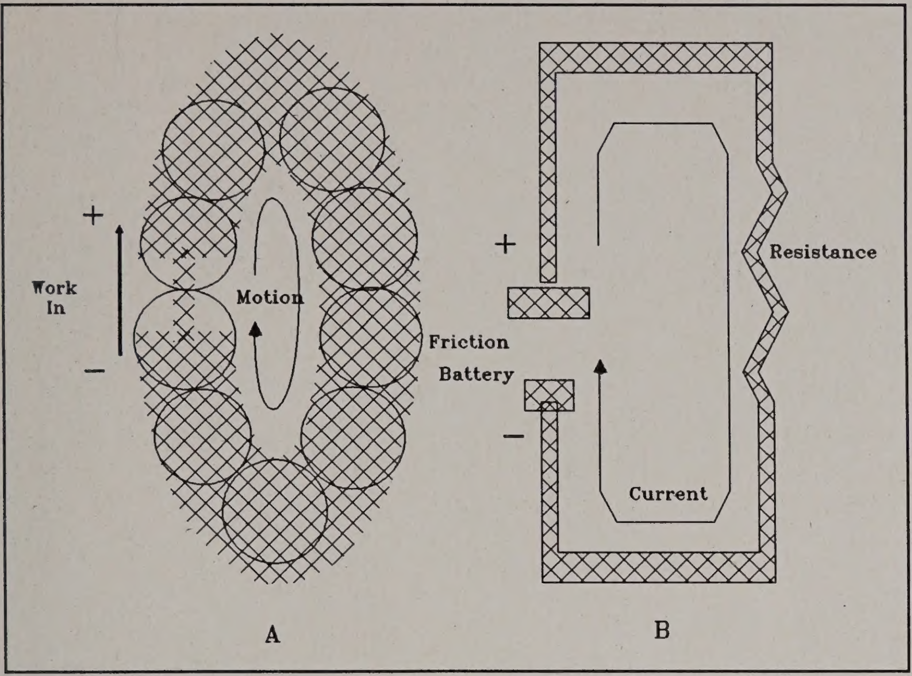
3.) You must do work to keep the balls moving.

4.) The balls are not used up nor compressed (one ball in one out)

5.) The balls move from negative to positive where the work is done to move the charge (the battery or generator)

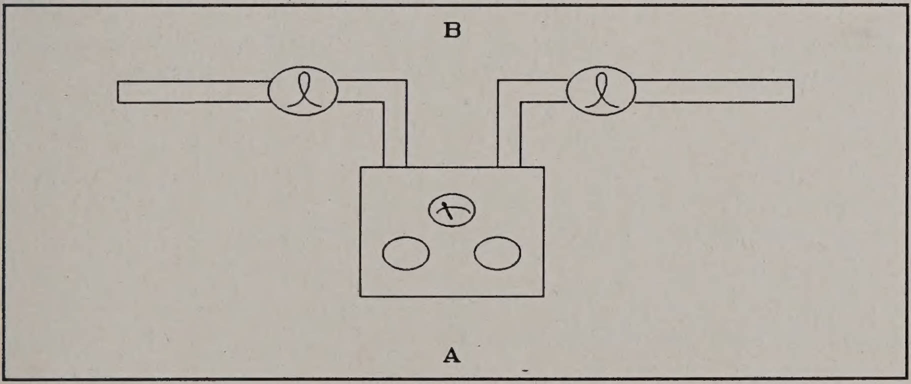
This model has led us to the idea of a circuit (see B in the illustration above). However, you do not need a circuit to have a current -- even from a battery!





Consider first an AC example of current flow without a circuit.

The six meter transmitter A is connected to a six meter half wave dipole antenna B. The transmitter sucks the electrons out of the left side of the antenna and pushes them into the right side. The left arm of the antenna is positively charged, the right side is negatively charged. The light bulbs (resistors which glow because they are so hot) light. There is really current flowing. Next the transmitter sucks electrons from the right arm of the antenna and pushes them into the left arm -- again the bulbs light. Actually, of course, the bulb filament remains hot during the short period when little or no current is flowing. As promised electric current and no circuit.



Some of the largest direct currents (lightning for example) occur along conduction paths which are not circuits. In these situations a large charged body is moved mechanically into contact with or close to an oppositely charged or neutral body. Once contact is established and to a lesser extent while the relative position of the bodies is changing, charge moves around in the system until the energy of the system is a minimum. This moving charge is a current. It can and does cause light, heat, and turns CMOS chips into useless pieces of silicon. The charged bodies involved sooner or later become more charged, less charged, neutral or oppositely charged. No charge is ever created or destroyed. The preliminary charging and subsequent redistribution of charge duc in part to mechanical motion involving minutes, hours or even days and not requiring a path of conducting material can hardly be called a circuit. However the short duration -- typically a few microseconds -- arc through the ionized conducting medium (air) and the flow of charge through conductors immediately adjacent and connected to the arc is certainly an electric current.

In metals the charge carriers -- charged particles that move -- are electrons. The flow of electrons which are negatively charged particles is opposite to the flow of current. Current is defined to flow in the direction that positive charge carriers would move due to the electromotive force. In semiconductors the charge carriers are electrons and minority charge carriers -- usually positive. In liquids the flow of charge -- electrophoresis -- is due to the motion of charged molecules. In a vacuum, current can involve a motion of either electrons or charged atoms, molecules or particles of matter. In air a current is due to the motion of electrons, ions (charged molecules) or charged aerosols.

The most important of these to an understanding of the electronic circuitry used in amateur communications is the current in metallic conductors. The methods of measuring, calculating, and using the flow of electrical currents will be the subjects of future discussions.

* * *

QRX

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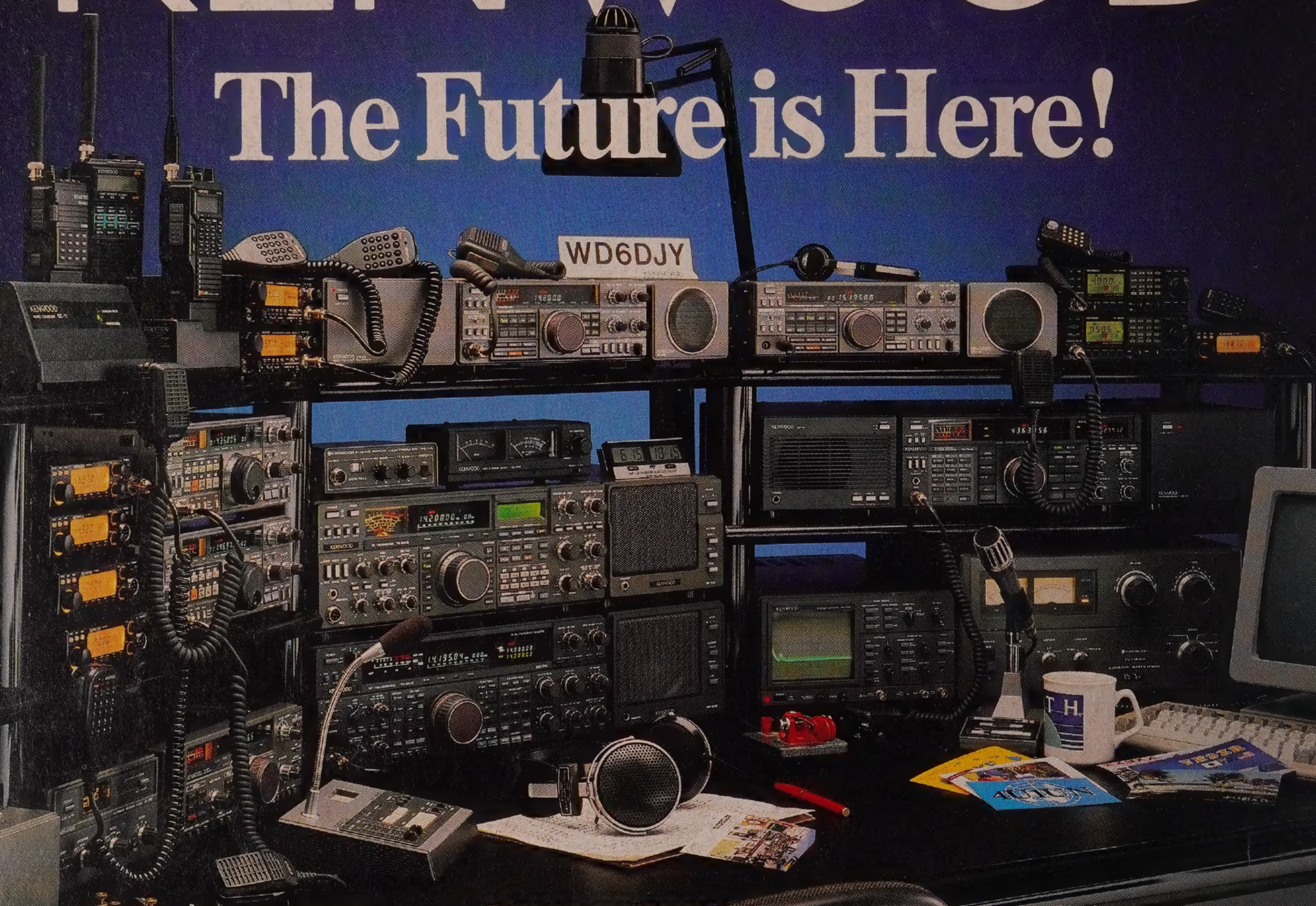

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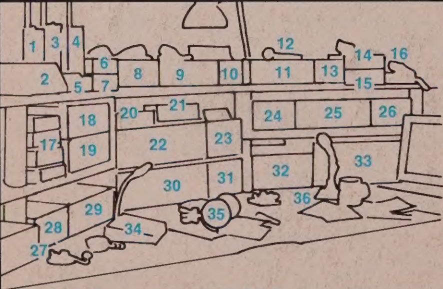

1) TH-26AT: Compact HT. **2) BC-11:** Rapid Charger for TH-26AT. **3) TH-315A:** 220 Deluxe HT. **4) TH-75A:** Dual Band HT. **5) BC-10:** Compact Charger. **6 & 7) TM-631A/731A:** 144–220/144–450 MHz FM Dual Banders **8) PS-50:** Heavy Duty Power Supply. **9) TS-440S:** HF Transceiver w/AT-440 (shown w/supplied MC-43S). **10) SP-430:** External Speaker. **11) R-5000:** High Performance Receiver. **12) HS-6:** Small-size Headphones. **13) SP-430. 14) TM-2530A:** Deluxe 2m, 25 W FM Transceiver (w/optional MC-48B mic.). **15) TM-3530A:** Deluxe 220 MHz, 25 W FM Transceiver. **16) TM-701A:** 144/450 MHz Compact Dual Bander Mobile Transceiver. **17) TM-231A/331A/431A/531A:** 144, 220, 450, 1200 MHz Compact Mobile Transceivers. **18) TS-811A:** 70 cm, 25 W and **19) TS-711A:** 2m, 25 W, All Mode Base Station Transceivers. **20) PC-1A:** Phone Patch (FCC part 68 Registered). **21) SW-2100:** SWR/Power Meter. **22) TS-940S:** Deluxe HF Transceiver w/AT-940 installed. **23) SP-940:** Matching External Speaker. **24) SP-31:** External Speaker. **25) TS-790A:** All Mode Tri-band Satellite Transceiver. **26) PS-31:** Matching Power Supply. **27) PS-430:** Power Supply. **28) AT-250:** External Automatic Antenna Tuner. **29) TS-680S:** 160-6 m Multi-Bander. **30) TS-950SD:** HF Transceiver w/DSP. **31) SP-950:** Matching External Speaker. **32) SM-230:** Deluxe Station Monitor. **33) TL-922A:** HF Linear Amplifier. **34) MC-85:** Multi-function Desk Mic. w/3 outputs and tone controls. **35) HS-5:** Deluxe Headphones. **36) MC-60A:** Base Station Mic.

As the "pacesetter" in Amateur Radio, Kenwood continues to incorporate tomorrow's techniques and innovations into practical products today. Digital Signal Processing (DSP) in the TS-950SD is only one example. SSB Slope Tuning, the original "Dual Bander" concept, built-in antenna tuners for HF rigs, and many other techniques were all developed by Kenwood, and imitated by others. Leading edge technology, and superior field-proven performance — That's the Kenwood Experience!

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